DEPARTMENT OF THE INTERIOR
JOHN BARTON PAYNE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

BULLETIN 712

# MINERAL RESOURCES OF ALASKA

## REPORT ON PROGRESS OF INVESTIGATIONS IN

## 1918

BY

G. C. MARTIN AND OTHERS



WASHINGTON
GOVERNMENT PRINTING OFFICE
1920

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# MINERAL RESOURCES OF ALASKA, 1918.

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## PREFACE.

By G. C. MARTIN.

This volume is the fifteenth of a series of annual bulletins[1] treating of the mining industry of Alaska and summarizing the results achieved during the year in the investigation of the mineral resources of the Territory. These reports are intended to give prompt publication of the more valuable economic results of the year. The time available for their preparation does not permit full office study of the field notes and specimens, and some of the statements made here may be subject to modification when the study has been completed. Those interested in any particular district should therefore procure a copy of the complete report on that district as soon as it is available.

This volume, like the others of the series, contains an account of the mining industry, including statistics of mineral production, and also preliminary statements on investigations made by the Geological Survey. It is intended that this series of reports shall serve as convenient reference works on the mining industry for the years which they cover. It is not possible for a member of the Survey to visit every mining district each year, and therefore the information used in preparing the summary on mining developments is in part obtained from other reliable sources. The number of important mining districts that were not visited by Survey geologists was larger in 1918 than usual, because the staff of the Alaska division of the Geological Survey had been depleted by the entrance of most of the geologists into the Army or into various activities connected with the prosecution of the war. The Geological Survey is consequently under even greater obligation than in past years to the residents of the Territory and others who have supplied valuable information. Those who have thus aided in the preparation of this report include

[1] The preceding volumes in this series are U. S. Geol. Survey Bulls. 259, 284, 314, 345, 379, 442, 480, 520, 542, 592, 622, 642, 662, and 692.

the many mine operators who have made reports on production and developments, especially those who responded to the appeal for advance information concerning their mining activities. The Director and the officers of the Mint, the officers of the Alaska customs service, the members and officers of the Alaska Engineering Commission, the officers of the American Railway Express Co., many other Federal and Territorial officials, the Seattle Chamber of Commerce, and many officers of transportation and commercial companies have contributed valuable data for this report. It is impossible to enumerate all the individuals and mining companies who have supplied the customary information concerning their own activities, but grateful acknowledgment must be made to those who have furnished other special information, among whom are the following: The late Hon. Charles A. Sulzer; P. R. Bradley and G. T. Jackson, of Juneau; George C. Hazelet, of Cordova; E. T. Stannard, of Kennicott; G. Howard Birch, of Dan Creek; F. LeRoy Thurmond, of Anchorage; the late U. G. Myers, of Eagle; J. A. Kemp, of Steel Creek; Thomas Hunter, of Circle; O. J. Nicholson, of White Eye; J. A. Fairborn, H. A. St. George, E. A. Suter, Volney Richmond, R. C. Wood, First National Bank, and Farmers' Bank of Fairbanks; Charles Zielke, of Nenana; Alexander Mitchell, of Kantishna; George L. Morrison, of Hot Springs; George Wesch, of Livengood; George W. Ledger, of Rampart; Frank Cook, of Ruby; C. A. Boerner, Charles Ross, and Miners and Merchants' Bank, of Iditarod; Henry Howard, of Flat; W. F. Green, of McGrath; Harry Madison, of Tolstoi; G. A. Stecker, of Quinhagak; E. W. Quigley, Alaska Banking & Safe Deposit Co., and Miners and Merchants' Bank, of Nome; and George L. Stanley, of Kiana.

# ADMINISTRATIVE REPORT.

By G. C. Martin.

## INTRODUCTION.

Ten parties were engaged during 1918 in Alaska surveys and investigations. The length of the field season ranged from 2 to 12 months, being determined by the character of the work and by the climatic conditions prevailing in different parts of the territory. The parties included 8 geologists, 1 topographer, 1 engineer, and 20 packers, cooks, and other auxiliaries. Eight of the parties were engaged in geologic surveys, one in topographic surveys, and one in stream gaging. The areas covered by reconnaissance geologic surveys on a scale of 1:250,000 (4 miles to an inch) amount to 3,500 square miles. Much of the time of the geologists was devoted to the investigation of special problems relating to the occurrence of minerals, the results of which can not be expressed in terms of area. About 1,200 square miles was covered by reconnaissance topographic surveys on a scale of 1:250,000 (4 miles to an inch). In cooperation with the Forest Service, stream gaging was continued in southeastern Alaska.

Of the parties whose work may be classified geographically, three parties worked in southeastern Alaska, three in the Cook Inlet-Susitna region, one in the Yukon basin, and two in Seward Peninsula.

The funds available for field and office work relating to the field season of 1918 included an appropriation of $75,000 and an allotment of a statutory salary of $2,000 for the fiscal year ending June 30, 1919, and the unexpended balance of the appropriation for the year ending June 30, 1918, of which about $15,800 was used in equipping parties for the season's field work. The following tables show the allotments, including both field and office work, of the total funds classified by regions, by kinds of surveys, and by kinds of expenditures. In the first table the general office expenses are apportioned to the several allotments, account being taken of variations in character of work. The results are expressed in round numbers. Salaries of the permanent staff, other fixed charges, and the total allotments

for the work of the office at Auchorage are included up to the end of the fiscal year 1919, but expenses other than these include only the cost of field and office work during 1918. The " general investigations " include, among other things, the cost of collecting mineral statistics, of office work relating to the field investigations of previous seasons, and of investigations under the direct administration of the geologic branch. A balance of about $16,500 from the appropriation for the year ending June 30, 1919, is available for equipping the field parties in 1919.

*Approximate general distribution of appropriations for Alaska investigations, field season 1918.*

| | 1917–18 | 1918–19 |
|---|---|---|
| Southeastern Alaska | $3,000 | $15,800 |
| Copper River and Prince William Sound | | 1,300 |
| Cook Inlet and Susitna basin | 4,400 | 19,700 |
| Yukon basin | 3,900 | 8,500 |
| Seward Peninsula | 4,500 | 7,300 |
| General investigations | | 7,900 |
| To be allotted to field work, 1919 | | 16,500 |
| | 15,800 | 77,000 |

*Approximate allotments to different kinds of surveys and investigations, field season 1918.*

| | 1917–18 | 1918–19 |
|---|---|---|
| Reconnaissance geologic surveys | $10,200 | $13,000 |
| Special geologic investigations | 3,350 | 17,500 |
| Reconnaissance topographic surveys | 2,250 | 4,300 |
| Investigation of water resources | | 5,100 |
| Collection of mineral statistics | | 1,800 |
| Miscellaneous, including administration, inspection, clerical salaries, office supplies and equipment, and map compilation | | 18,800 |
| To be allotted to field work, 1919 | | 16,500 |
| | 15,800 | 77,000 |

*Allotments for salaries and field expenses, field season 1918.*

| | 1917–18 | 1918–19 |
|---|---|---|
| Scientific and technical salaries | | $26,328 |
| Field expenses | $15,800 | 20,259 |
| Clerical and administrative salaries and miscellaneous expenses | | 13,913 |
| To be allotted to field work, 1919 | | 16,500 |
| | 15,800 | 77,000 |

The following table exhibits the progress of investigations in Alaska and the annual grant of funds since systematic surveys were begun in 1898. It should be noted that a varying amount is spent each year on special investigations that yield results which can not be expressed in terms of area.

*Progress of surveys in Alaska, 1898–1918.*

| Year. | Appropriation. | Areas covered by geologic surveys. | | | Areas covered by topographic surveys.[a] | | | | | Water resources investigations. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Exploratory (scale 1:625,000 or 1:1,000,000). | Reconnaissance (scale 1:250,000). | Detailed (scale 1:62,500). | Exploratory (scale 1:625,000 or 1:1,000,000). | Reconnaissance (scale 1:250,000; 200-foot contours). | Detailed (scale 1:62,500; 25, 50, or 100 foot contours). | Lines of levels. | Bench marks set. | Gaging stations maintained part of year. | Stream volume measurements. |
| | | *Sq. m.* | *Sq. m.* | *Sq. m.* | *Sq. m.* | *Sq. m.* | *Sq. m.* | *Miles.* | | | |
| 1898 | $46,189 | 9,500 | | | 12,840 | 2,070 | | | | | |
| 1899 | 25,000 | 6,000 | | | 8,690 | | | | | | |
| 1900 | 60,000 | 3,300 | 6,700 | | 630 | 11,150 | | | | | |
| 1901 | 60,000 | 6,200 | 5,800 | | 10,200 | 5,450 | | | | | |
| 1902 | 60,000 | 6,950 | 10,050 | | 8,330 | 11,970 | 96 | | | | |
| 1903 | 60,000 | 5,000 | 8,000 | 96 | | 15,000 | | | | | |
| 1904 | 60,000 | 4,050 | 3,500 | | 800 | 6,480 | 480 | 86 | 19 | | |
| 1905 | 80,000 | 4,000 | 4,100 | 536 | | 4,880 | 787 | 202 | 28 | | |
| 1906 | 80,000 | 5,000 | 4,000 | 421 | | 13,500 | 40 | | | 14 | 286 |
| 1907 | 80,000 | 2,600 | 1,400 | 442 | | 6,120 | 501 | 95 | 16 | 48 | 457 |
| 1908 | 80,000 | 2,000 | 2,850 | 604 | | 3,980 | 427 | 76 | 9 | 53 | 556 |
| 1909 | 90,000 | 6,100 | 5,500 | 450 | 6,190 | 5,170 | 444 | | | 81 | 703 |
| 1910 | 90,000 | | 8,635 | 321 | | 13,815 | 36 | | | 69 | 429 |
| 1911 | 100,000 | 8,000 | 10,550 | 496 | | 14,460 | 246 | | | 68 | 309 |
| 1912 | 90,000 | | 2,000 | 525 | | | 298 | | | 69 | 381 |
| 1913 | 100,000 | 3,500 | 2,950 | 180 | 3,400 | 2,535 | 287 | | | | |
| 1914 | 100,000 | 1,000 | 7,700 | 325 | 600 | 10,300 | 10 | | | | |
| 1915 | 100,000 | | 10,700 | 200 | | 10,400 | 12 | 3 | 2 | 9 | |
| 1916 | 100,000 | | 5,100 | 636 | | 9,700 | 67 | | | 20 | |
| 1917 | 100,000 | | 1,750 | 275 | | 1,050 | | | | 19 | |
| 1918 | 77,000 | | 3,500 | | | 1,200 | | | | | |
| | 1,638,189 | 73,200 | 104,785 | 5,507 | 51,680 | 149,230 | 3,731 | 462 | 74 | | |
| Percentage of total area of Alaska | | 12.48 | 17.87 | 0.94 | 8.81 | 25.45 | 0.64 | | | | |

[a] The Coast and Geodetic and International Boundary surveys and the General Land Office have also made topographic surveys in Alaska. The areas covered by these surveys are, of course, not included in these totals.

## GEOGRAPHIC DISTRIBUTION OF INVESTIGATIONS.

### GENERAL WORK.

Alfred H. Brooks, geologist in charge of the division of Alaskan mineral resources, now lieutenant colonel of the Corps of Engineers, United States Army, and chief geologist of the American Expeditionary Force, has been engaged in military duty in France throughout the year.

The writer was engaged in office work till July 26, when he started for Alaska. The time from August 12 to August 26 was devoted to a review of mining developments and the collection of statistics in the Fairbanks district. Some of the mines in the Chitina Valley were visited during the first week in September. He then spent one day in consultation with Mr. Chapin concerning the work of the office in Anchorage and returned to Washington on September 26.

In the office the writer devoted 66 days to the preparation of the progress, administrative, and statistical reports, 10 days to revision of papers and proof reading, 12 days to the preparation of the annual press bulletin, 10 days to field plans, and 141 days to administrative and miscellaneous duties.

During the writer's absence in Alaska F. H. Moffit was acting geologist in charge and devoted considerable time to executive work.

During the absence of Capt. E. M. Aten, who is still in military service, Miss Lucy M. Graves has continued as office assistant to the acting geologist in charge, and T. R. Burch has assisted in the collection and compilation of mineral statistics.

Maj. J. W. Bagley and Capt. C. E. Giffin have been engaged in military service throughout the year. George L. Harrington entered military service as first lieutenant on June 21.

## SOUTHEASTERN ALASKA.

Field work in southeastern Alaska included special investigations of Carboniferous stratigraphy and paleontology, a geologic reconnaissance of parts of Chichagof and Admiralty islands, and a continuation of the investigation of water resources.

The investigation of the water resources of southeastern Alaska, begun in 1915 under a cooperative agreement with the Forest Service, was continued throughout 1918. G. H. Canfield, who had charge of this work, maintained automatic gages throughout the year. In addition to these gages, others were installed in cooperation with individuals and corporations. The results are briefly summarized in another section of this report. This work could not have been carried on without the cordial cooperation of the Forest Service, many members of which have given substantial aid; particular acknowledgment should be made to W. G. Weigle, special agent at Ketchikan, and to Philip H. Dater, district engineer at Portland, Oreg.

A reconnaissance of the geology and mineral deposits of Admiralty Island and of the eastern part of Chichagof Island was made by Edwin Kirk. Field work was begun on May 31 and continued till August 27. An area of about 1,500 square miles was mapped on the scale of 1:200,000.

A study of the Carboniferous rocks of southeastern Alaska was assigned to George H. Girty, who studied the stratigraphy and made large collections of fossils from June 1 to July 30.

## COOK INLET AND SUSITNA REGIONS.

Because of the importance of the region tributary to the Government railroad, and the growing demand for information concerning it, a special effort is being made to complete the mapping of that

region. The surveys and investigations in the Cook Inlet and Susitna regions in 1918 included a topographic reconnaissance survey of an area between Talkeetna River and Broad Pass, detailed investigations at the coal mines in the Matanuska Valley, and investigations of the chromite deposits of Cook Inlet.

A topographic reconnaissance survey of an area adjacent to the Government railroad between Talkeetna River and Broad Pass was made by D. C. Witherspoon from June 20 to September 19. An area of about 1,200 square miles was mapped on a scale of 1:180,000.

A special investigation of the chromite deposits of Port Chatham and Red Mountain, on lower Cook Inlet, was made by Prof. A. C. Gill, of Cornell University, who was engaged in field work from July 1 to August 25.

### YUKON REGION.

A geologic reconnaissance survey of the Tolovana placer district was made by R. M. Overbeck, who was engaged in this work from June 18 to September 25. An area of about 2,000 square miles was mapped on the scale of 1:250,000. Mr. Overbeck also collected data on the production of placer gold in the Tolovana and Rampart districts.

The placer and lode mines of the Fairbanks district were visited by G. C. Martin from August 11 to 26, for the purpose of obtaining information concerning recent mining conditions and developments.

### SEWARD PENINSULA.

A special examination of the tin deposits of the York district was made by Edward Steidtmann and S. H. Cathcart, who devoted the time from July 5 to September 16 to this work. Studies were made of the extent, occurrence, and origin of the known tin deposits, and of the stratigraphy and structure of the rocks associated with them. An area of about 50 square miles was mapped geologically on the scale of 1:125,000, and the reconnaissance mapping of additional areas was revised.

After the end of field work in the York district S. H. Cathcart made investigations of general mining developments in Seward Peninsula. He was engaged in this work till October 28.

### ALASKA OFFICE.

A branch office of the Geological Survey was opened at Anchorage in June. This office is in charge of Theodore Chapin and will be his general headquarters throughout the year. The main purpose in opening this office is to provide the means of close cooperation between the Geological Survey and those in charge of the operation of the Government coal mines in the Matanuska Valley. It will

also be the purpose of the resident geologist to do everything possible to aid the mining industry in the region tributary to the Government railroad, to keep in close touch with all local developments in mining and prospecting, and to furnish whatever aid may be possible through the giving of information, advice, and publications to all who are engaged in mining and prospecting.

## COLLECTION OF STATISTICS.

The collection of statistics of production of metals in Alaska, begun by the Alaska division in 1905, was continued as usual. Preliminary estimates of mineral production for the previous year were published on January 1.

## PUBLICATIONS.

During 1918 the Survey published four bulletins and one professional paper relating to Alaska. In addition, one professional paper and five bulletins were in press, and eighteen reports, including this volume, were in preparation at the end of the year. Five topographic maps were published, and eight were in press at the end of the year.

### REPORTS ISSUED.

Professional Paper 120-D. The structure and stratigraphy of Gravina and Revillagigedo islands, Alaska, by Theodore Chapin.

Bulletin 655. The Lake Clark-central Kuskokwim region, Alaska, by P. S. Smith.

Bulletin 662. Mineral resources of Alaska, 1916, by Alfred H. Brooks and others.

Bulletin 667. The Cosna-Nowitna region, Alaska, by H. M. Eakin.

Bulletin 675. The upper Chitina Valley, Alaska, by F. H. Moffit, with a description of the igneous rocks, by R. M. Overbeck.

### REPORTS IN PRESS.

Professional Paper 109. The Canning River region, northern Alaska, by E. deK. Leffingwell. (Published Mar. 6, 1919.)

Bulletin 668. The Nelchina-Susitna region, Alaska, by Theodore Chapin. (Published Mar. 19, 1919.)

Bulletin 664. The Nenana coal field, Alaska, by G. C. Martin. (Published Apr. 22, 1919.)

Bulletin 683. The Anvik-Andreafski region, Alaska, by G. L. Harrington. (Published May 20, 1919.)

Bulletin 687. The Kantishna region, Alaska, by S. R. Capps. (Published June 21, 1919.)

Bulletin 692. Mineral resources of Alaska, 1917, by G. C. Martin and others.

### REPORTS SUBMITTED FOR PUBLICATION.

Bulletin 682. The marble resources of southeastern Alaska, by E. F. Burchard.

Bulletin 699. The Porcupine district, Alaska, by H. M. Eakin.

A geologic reconnaissance in the northern part of the Yukon-Tanana region, Alaska, by Eliot Blackwelder.

### REPORTS IN PREPARATION.

Geology of the Glacier Bay and Lituya region, Alaska, by F. E. Wright and C. W. Wright.

Geology of the region along the international boundary from Porcupine River to the Arctic Ocean, by A. G. Maddren.

The upper Matanuska basin, Alaska, by G. C. Martin.

The Yakataga district, Alaska, by A. G. Maddren.

The Mesozoic stratigraphy of Alaska, by G. C. Martin.

The Kotsina-Kuskulana district, Alaska, by F. H. Moffit.

The lower Kuskokwim region, Alaska, by A. G. Maddren.

The Ruby-Kuskokwim region, Alaska, by J. B. Mertie, jr., and G. L. Harrington.

The Cretaceous and Tertiary floras of Alaska, by Arthur Hollick.

The Juneau district, Alaska, by A. C. Spencer and H. M. Eakin.

The Ketchikan district, Alaska, by Theodore Chapin.

The geology and mineral resources of Latouche and Knight Island districts, Alaska, by B. L. Johnson.

The Port Valdez and Jack Bay district, Alaska, by B. L. Johnson.

The western Talkeetna Mountains, Alaska, by S. R. Capps.

### TOPOGRAPHIC MAPS ISSUED.

Lower Matanuska Valley, by R. H. Sargent; scale, 1:62,500; contour interval, 50 feet. Sale edition.

Reconnaissance map of Cosna-Nowitna region, Alaska, by H. M. Eakin, C. E. Giffin, and R. B. Oliver; scale, 1:250,000; contour interval, 200 feet. (Plate I, Bulletin 667.)

Reconnaissance map of Lake Clark-central Kuskokwim region, Alaska, by R. H. Sargent, D. C. Witherspoon, and C. E. Giffin; scale 1:250,000; contour interval, 200 feet. (Plate I, Bulletin 655.)

Reconnaissance map of upper Chitina Valley, Alaska, by International Boundary Commission, F. H. Moffit, D. C. Witherspoon, and T. G. Gerdine; scale, 1:250,000; contour interval, 200 feet. (Plate I, Bulletin 675.)

Juneau and vicinity, Alaska, by D. C. Witherspoon; scale, 1:24,000; contour interval, 50 feet. Sale edition.

### TOPOGRAPHIC MAPS IN PRESS.

Canning River region, by E. deK. Leffingwell; scale, 1:250,000; sketch contours. (Published Mar. 6, 1919, as Plate I, Professional Paper 109.)

North Arctic coast, by E. deK. Leffingwell; scale, 1:500,000; no contours. (Published Mar. 6, 1919, as Plate III, Professional Paper 109.)

Coast line between Challenge Entrance and Thetis Island, by E. deK. Leffingwell; scale, 1:125,000; no fixed contour interval. (Published Mar. 6, 1919, as Plate IV, Professional Paper 109.)

Coast line between Martin Point and Challenge Entrance, by E. deK. Leffingwell; scale, 1:125,000; no fixed contour interval. (Published Mar. 6, 1919, as Plate V, Professional Paper 109.)

Nelchina-Susitna region, by J. W. Bagley; scale, 1:250,000; contour interval, 200 feet. (Published Mar. 19, 1919, as Plate I, Bulletin 668.)

Anvik-Andreafski region, by R. H. Sargent; scale, 1:250,000; contour interval, 100 feet. (Published May 20, 1919, as Plate I, Bulletin 683.)

Marshall mining district, by R. H. Sargent; scale, 1:125,000; contour interval, 100 feet. (Published May 20, 1919, as Plate II, Bulletin 683.)

Kantishna region, by C. E. Giffin; scale, 1:250,000; contour interval, 200 feet. (Published May 20, 1919, as Plate I, Bulletin 687.)

TOPOGRAPHIC MAPS READY FOR ENGRAVING.

Kotsina-Kuskulana district, by D. C. Witherspoon; scale, 1:62,500; contour interval, 100 feet.

Lower Kuskokwim region, by A. G. Maddren; scale, 1:500,000; contour interval, 400 feet.

Ruby district, by C. E. Giffin and R. H. Sargent; scale, 1:250,000; contour interval, 200 feet.

TOPOGRAPHIC MAPS IN PREPARATION.

Innoko-Iditarod region, by R. H. Sargent and C. E. Giffin; scale, 1:250,000; contour interval, 200 feet.

Anchorage-Matanuska region, by J. W. Bagley and others; scale, 1:250,000; contour interval, 200 feet.

Yukon-Tanana Valley; compiled; scale, 1:500,000; contour interval, 400 feet.

Glacier Bay region; compiled; scale, 1:250,000; contour interval, 200 feet.

Port Wells region, by J. W. Bagley; scale, 1:250,000; contour interval, 200 feet.

Jack Bay district, by J. W. Bagley; scale, 1:62,500; contour interval, 50 feet.

Fidalgo-Gravina district, by D. C. Witherspoon; scale, 1:250,000; contour interval, 200 feet.

Susitna-Chulitna district, by D. C. Witherspoon; scale, 1:250,000; contour interval, 200 feet.

Seward-Fairbanks route; compiled; scale, 1:250,000; contour interval, 200 feet

# THE ALASKAN MINING INDUSTRY IN 1918.

By G. C. Martin.

## GENERAL FEATURES.

The mineral production of Alaska in 1918 was valued at $28,253,961. This output was almost $12,500,000 less than that for 1917 and was the smallest since 1914. The decrease was chiefly in copper, the production of which fell from 88,783,400 pounds, valued at $24,240,-598, in 1917 to 69,224,951 pounds, valued at $17,098,563, in 1918. The reduction in the output of copper was due to shortage of labor and ships. The production of gold decreased from 709,050 ounces, valued at $14,657,353, in 1917 to 458,641 ounces, valued at $9,480,953, in 1918, and was the smallest since 1904. The reduction in the output of gold was due chiefly to curtailment of operations because of the scarcity of labor and the high cost of materials. There was a reduction in the output of silver and lead due to the decrease in gold and copper. The production of tin, tungsten, and antimony showed a considerable decrease, the production of antimony practically ceasing because of the inability of the producers in the interior of Alaska to compete with the cheaper foreign product. The production of coal increased from 53,955 tons, valued at $265,317, in 1917 to 75,606 tons, valued at $411,850, in 1918, and was the largest in the history of mining in Alaska. Petroleum continued to be produced from the single patented claim near Katalla, and the local refinery was operated on about the customary scale. The production of marble and gypsum in southeastern Alaska was somewhat less than in 1916. Chromite was mined in about the same amount as in 1917. The production of platinum, which was begun in 1916, continued on an increased scale, chiefly from the placers in Seward Peninsula. A considerable amount of palladium was recovered from copper ore from southeastern Alaska.

The statistics for the mineral production of Alaska for the last two years are given in the following table. The minor metallic and nonmetallic products are grouped, because a separate listing might reveal the production of individual properties.

*Mineral output of Alaska, 1917 and 1918.*

| | 1917 | | 1918 | | Decrease or increase in 1918. | |
|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| Copper..............pounds.. | 88,793,400 | $24,240,598 | 69,224,951 | $17,098,563 | −19,568,449 | −$7,142,033 |
| Gold............fine ounces.. | 709,050 | 14,657,353 | 458,641 | 9,480,952 | − 250,409 | − 5,176,401 |
| Silver..................do.... | 1,239,150 | 1,021,060 | 847,789 | 847,789 | − 391,361 | − 173,266 |
| Coal..............short tons.. | 53,955 | 265,317 | 75,606 | 411,850 | + 21,651 | + 146,533 |
| Tin, metallic...........do.... | 100 | 123,300 | 68 | 118,000 | − 32 | − 5,300 |
| Lead..................do.... | 852 | 146,584 | 564 | 80,088 | − 288 | − 66,496 |
| Miscellaneous metallic products, including chrome ore, tungsten, antimony, platinum, and palladium....... | ............ | a118,500 | ............ | 96,100 | ............ | − 22,400 |
| Miscellaneous nonmetallic products, including petroleum, marble, gypsum, and lime.................... | ............ | b137,500 | ............ | 120,619 | ............ | − 16,881 |
| | ............ | 40,710,212 | ............ | 28,253,961 | ............ | 12,456,244 |

a No palladium included. b Some graphite included.

Regular mining may be said to have begun in Alaska in 1880, when the Juneau gold placers were first exploited. It is estimated that since that time mineral wealth has been produced to the value of more than $418,000,000.

*Value of total mineral production of Alaska, 1880–1918.*

| By years. | | | | By substances. | |
|---|---|---|---|---|---|
| 1880–1890.............. | $4,686,714 | 1906.............. | $23,378,428 | Gold.............. | $302,238,961 |
| 1891.............. | 916,920 | 1907.............. | 20,850,235 | Copper.............. | 105,743,033 |
| 1892.............. | 1,098,400 | 1908.............. | 20,145,632 | Silver.............. | 5,598,314 |
| 1893.............. | 1,051,610 | 1909.............. | 21,146,953 | Coal.............. | 1,096,913 |
| 1894.............. | 1,312,567 | 1910.............. | 16,887,244 | Tin.............. | 844,572 |
| 1895.............. | 2,388,042 | 1911.............. | 20,691,241 | Lead.............. | 449,496 |
| 1896.............. | 2,981,877 | 1912.............. | 22,536,849 | Antimony.............. | 237,500 |
| 1897.............. | 2,540,401 | 1913.............. | 19,476,356 | Marble, gypsum, petroleum, etc.......... | 2,331,303 |
| 1898.............. | 2,587,815 | 1914.............. | 19,065,666 | | 418,540,092 |
| 1899.............. | 5,706,226 | 1915.............. | 32,854,229 | | |
| 1900.............. | 8,241,734 | 1916.............. | 48,632,212 | | |
| 1901.............. | 7,010,838 | 1917.............. | 40,700,205 | | |
| 1902.............. | 8,403,153 | 1918.............. | 28,253,961 | | |
| 1903.............. | 8,944,134 | | 418,540,092 | | |
| 1904.............. | 9,569,715 | | | | |
| 1905.............. | 16,480,762 | | | | |

## GOLD AND SILVER.

The following table gives an estimate of the total production of gold and silver since the beginning of mining in 1880. For the earlier years the figures, especially for silver, are probably far from being correct, but they are based on the best information now available.

*Gold and silver produced in Alaska, 1880–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Commercial value. |
| 1880 | 967 | $20,000 | | |
| 1881 | 1,935 | 40,000 | | |
| 1882 | 7,256 | 150,000 | | |
| 1883 | 14,561 | 301,000 | 10,320 | $11,146 |
| 1884 | 9,724 | 201,000 | | |
| 1885 | 14,512 | 300,000 | | |
| 1886 | 21,575 | 446,000 | | |
| 1887 | 32,653 | 675,000 | | |
| 1888 | 41,119 | 850,000 | 2,320 | 2,181 |
| 1889 | 43,538 | 900,000 | 8,000 | 7,490 |
| 1890 | 36,862 | 762,000 | 7,500 | 6,071 |
| 1891 | 43,538 | 900,000 | 8,000 | 7,920 |
| 1892 | 52,245 | 1,080,000 | 8,000 | 7,000 |
| 1893 | 50,213 | 1,038,000 | 8,400 | 6,570 |
| 1894 | 62,017 | 1,282,000 | 22,261 | 14,257 |
| 1895 | 112,642 | 2,328,500 | 67,200 | 44,222 |
| 1896 | 138,401 | 2,861,000 | 145,300 | 99,087 |
| 1897 | 118,011 | 2,439,500 | 116,400 | 70,741 |
| 1898 | 121,760 | 2,517,000 | 92,400 | 54,575 |
| 1899 | 270,997 | 5,602,000 | 140,100 | 84,276 |
| 1900 | 395,030 | 8,166,000 | 73,300 | 45,494 |
| 1901 | 335,369 | 6,932,700 | 47,900 | 28,598 |
| 1902 | 400,709 | 8,283,400 | 92,000 | 48,590 |
| 1903 | 420,069 | 8,683,600 | 143,600 | 77,843 |
| 1904 | 443,115 | 9,160,000 | 198,700 | 114,934 |
| 1905 | 756,101 | 15,630,000 | 132,174 | 80,165 |
| 1906 | 1,066,030 | 22,036,794 | 203,500 | 136,345 |
| 1907 | 936,043 | 19,349,743 | 149,784 | 98,857 |
| 1908 | 933,290 | 19,292,818 | 135,672 | 71,906 |
| 1909 | 987,417 | 20,411,716 | 147,950 | 76,934 |
| 1910 | 780,131 | 16,126,749 | 157,850 | 85,239 |
| 1911 | 815,276 | 16,853,256 | 460,231 | 243,923 |
| 1912 | 829,436 | 17,145,951 | 515,186 | 316,839 |
| 1913 | 755,947 | 15,626,813 | 362,563 | 218,988 |
| 1914 | 762,596 | 15,764,259 | 394,805 | 218,327 |
| 1915 | 807,966 | 16,702,144 | 1,071,782 | 583,393 |
| 1916 | 834,068 | 17,241,713 | 1,379,171 | 907,554 |
| 1917 | 709,050 | 14,657,353 | 1,239,150 | 1,021,060 |
| 1918 | 458,641 | 9,480,952 | 847,789 | 847,789 |
| | 14,620,810 | 302,238,961 | 8,389,308 | 5,598,314 |

The subjoined table gives an estimate, based on the best available data, of the gold and silver produced in Alaska from different sources since mining began in 1880. About $65,100,000 worth of gold, or about one-fifth of the total estimated output, was produced before 1905, and there is but scant information about its source. For the period since that time fairly complete statistical returns are available, and it is probable that the figures presented in the following table are sufficiently accurate to be valuable. The figures given for the silver recovered from placer gold and from siliceous ores are probably less accurate than those for the gold. Copper mining did not begin in Alaska until 1901, and the figures for gold and silver derived from this industry, as now presented, are therefore a close approximation to the actual output.

*Gold and silver produced in Alaska from different sources, 1880–1918.*

| Source. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| Siliceous ores [a] | 4,234,054 | $87,525,670 | 1,319,889 | $931,396 |
| Copper ores | 80,800 | 1,670,299 | 5,327,852 | 3,666,820 |
| Placers | 10,305,956 | 213,042,992 | 1,741,657 | 1,000,098 |
| | 14,620,810 | 302,238,961 | 8,389,398 | 5,598,314 |

[a] Including small amounts of lead ore.

The above table shows that about 29 per cent of the total gold production of Alaska has been obtained from the auriferous lode mines (siliceous ores). In 1918 the lode-gold production was 36.6 per cent; in 1917, 31 per cent; in 1916, 38 per cent; in 1915, 37 per cent; in 1914, 32 per cent; in 1913, 31.6 per cent; and in 1912, 29 per cent. In the following table the production of precious metals in 1918 has been distributed as to sources:

*Gold and silver produced in Alaska, 1918, by sources.*

| Source. | Ore (tons). | Gold. | | Silver. | |
|---|---|---|---|---|---|
| | | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| Siliceous ores | 2,095,577 | 168,021 | $3,473,317 | 90,064 | $90,064 |
| Copper ores | 722,047 | 5,207 | 107,635 | 719,391 | 719,391 |
| Placers | ............ | 285,413 | 5,900,000 | 38,334 | 38,334 |
| | 2,817,624 | 458,641 | 9,480,952 | 847,789 | 847,789 |

Twenty-five gold-lode mines were operated in 1918. There was also a production from 7 prospects—abandoned mines or small mines that were not in regular operation. Thirty-one mines were operated in 1917. The value of the lode-gold output decreased from $4,581,453 in 1917 to $3,473,317 in 1918. The decrease was due partly to the disaster at the Treadwell mine in April, 1917, and partly to curtailment of operations, especially in the Juneau district, because of shortage of labor. Southeastern Alaska, especially the Juneau district, is still the only center of large quartz-mining operations in the Territory. Next in importance is the Willow Creek lode district. The production in the Fairbanks district decreased materially, as the lode-mine owners of Fairbanks are still awaiting the cheapening of operating costs, especially of fuel, which is expected on the completion of the Government railroad. Most of the gold mines on Prince William Sound have suspended operations. The mill and

cyanide plant of the North Midas mine, in the Chitina Valley, Copper River district, was completed and began operating late in the year. Of the producing mines 6 were in southeastern Alaska, 1 in the Copper River district, 3 on Prince William Sound, 4 on Kenai Peninsula, 5 in the Willow Creek district, and 6 in the Fairbanks district. In 1918 the average value of the gold and silver contents for all siliceous ores mined was $1.70 a ton; the average for 1917 was $1.37 a ton. These averages reflect the dominance in the total lode production of the large tonnage produced from the low-grade ores of the Juneau district.

The production by districts of gold and silver in 1918 from gold-lode mines, including small amounts from a lead-silver mine which can not be given separately without disclosing an individual production, is given in the following table:

*Gold and silver produced from gold-lode mines in Alaska, 1918, by districts.*

| District. | Mines operated. | Ore mined (short tons). | Gold. | | Silver. | | Average value per ton of ore in gold and silver. |
|---|---|---|---|---|---|---|---|
| | | | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. | |
| Southeastern Alaska | [a] 6 | 2,085,915 | 152,755 | $3,157,732 | 88,053 | $88,053 | $1.56 |
| Prince William Sound [b] | [c] 4 | 444 | 638 | 13,195 | 490 | 490 | [d] 27.24 |
| Kenai Peninsula | 4 | 207 | 291 | 6,016 | 181 | 181 | 29.94 |
| Willow Creek | 5 | 7,976 | 13,043 | 269,624 | 724 | 724 | 33.90 |
| Fairbanks district [e] | [f] 6 | 1,035 | 1,294 | 26,750 | 616 | 616 | 26.44 |
| | 25 | 2,095,577 | 168,021 | 3,473,317 | 90,064 | 90,064 | 1.70 |

[a] Also clean-up material from 2 abandoned mines and shipments from one prospect.
[b] Including 1 mine in Copper River district.
[c] Also one prospect.
[d] Prince William Sound only.
[e] Includes some lead ore.
[f] Also three prospects.

The value of the placer gold produced in Alaska in 1918 was about $5,900,000. The production in 1917 was $9,810,000. The decrease in 1918 was general throughout the Territory, except in the Copper River and Yentna districts and some of the smaller Yukon districts. The decrease was due mainly to curtailment of operations because of shortage of labor, high cost of supplies, and uncertainty as to future conditions. Local decreases were due also to unfavorable climatic conditions and to the depletion of some of the richer placers.

It is estimated that about 574 placer mines were operated in the summer of 1918 and 153 during the previous winter, but many for only a part of the season. About 3,000 men were engaged in productive placer mining in the summer and 613 in the winter. In addition several hundred men were engaged in prospecting or other nonproductive work relating to placer mining. No important new placer-

bearing areas were discovered in 1918. The output and operations of placer mines in 1918 are shown by regions in the following table:

*Gold and silver produced from placer mines in Alaska, 1918, by regions.*

| Region. | Gold. | | Silver. | | Gravel handled (cubic yards). | Recovery per cubic yard. | Number of mines. | | Number of miners. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. | | | Summer. | Winter. | Summer. | Winter. |
| Southeastern Alaska | 483.750 | $10,000 | 80 | $80 | 10,000 | $1.00 | 5 | ...... | 12 | ...... |
| Copper River region | 11,561.625 | 239,000 | 1,158 | 1,158 | 198,000 | 1.20 | 22 | 4 | 124 | 7 |
| Cook Inlet and Susitna region | 7,740.000 | 160,000 | 1,185 | 1,185 | 386,000 | .41 | 24 | ...... | 134 | ...... |
| Southwestern Alaska | 145.125 | 3,000 | 23 | 23 | 2,000 | 1.50 | 5 | ...... | 13 | ...... |
| Yukon Basin | 206,271.000 | 4,264,000 | 28,831 | 28,831 | 2,197,000 | 1.94 | 355 | 121 | 1,965 | 490 |
| Kuskokwim region | 4,837.500 | 100,000 | 914 | 914 | 56,000 | 1.78 | 19 | ...... | 87 | ...... |
| Seward Peninsula | 53,599.500 | 1,108,000 | 6,022 | 6,022 | 2,076,000 | .53 | 128 | 21 | 633 | 99 |
| Norton Sound | 48.375 | 1,000 | 9 | 9 | .......... | 4.21 | 2 | 2 | 3 | 3 |
| Kobuk region | 725.625 | 15,000 | 112 | 112 | 6,000 | 2.50 | 14 | 5 | 35 | 14 |
| | 285,412.500 | 5,900,000 | 38,334 | 38,334 | 4,931,000 | 1.196 | 574 | 153 | 3,006 | 613 |

The following table shows approximately the total bulk of gravel mined annually since 1907 and the value of the gold recovered per cubic yard. The table is based in part on returns made by placer-mine operators and in part on known facts or assumptions concerning the richness of the gravels in the several districts. The figures for 1917, which differ somewhat from those previously published, are based on an assumption that the recoveries per cubic yard of the dredges in the Yukon region and Seward Peninsula, from which no reports were received, were the same as the average reported recoveries of the dredges in each region and that for the placer mines other than dredges the ratio of the recovery per cubic yard for the mines that supplied complete information as to the recovery per cubic yard for all mines was the same as in 1916. Although the table is thus only approximately correct, the amounts given are probably near the true figures.

*Gravel sluiced in Alaskan placer mines and value of gold recovered, 1908–1918.*

| Year. | Total quantity of gravel (cubic yards). | Value of gold recovered per cubic yard. | Year. | Total quantity of gravel (cubic yards). | Value of gold recovered per cubic yard. |
|---|---|---|---|---|---|
| 1908 | 4,275,000 | $3.74 | 1914 | 8,500,000 | $1.26 |
| 1909 | 4,418,000 | 3.66 | 1915 | 8,100,000 | 1.29 |
| 1910 | 4,036,000 | 2.97 | 1916 | 7,100,000 | 1.57 |
| 1911 | 5,790,000 | 2.17 | 1917 | 7,000,000 | 1.40 |
| 1912 | 7,050,000 | 1.70 | 1918 | 4,931,000 | 1.20 |
| 1913 | 6,800,000 | 1.57 | | | |

The table shows that from 1908 to 1914 there was a decline in the average gold content of the gravels mined. This decline reflects the improved methods of placer mining that have been introduced, more especially the increase in the use of dredges, which is brought out in the following table:

*Relation of recovery of placer gold per cubic yard to proportion produced by dredges.*

| | Percentage of placer gold produced by dredges. | Recovery per cubic yard. | | |
|---|---|---|---|---|
| | | Dredges. | Mines. | All placers. |
| 1911 | 12 | $0.60 | $3.36 | $2.17 |
| 1912 | 18 | .65 | 2.68 | 1.70 |
| 1913 | 21 | .54 | 3.11 | 1.57 |
| 1914 | 22 | .53 | 2.07 | 1.26 |
| 1915 | 22 | .51 | 2.33 | 1.29 |
| 1916 | 24 | .69 | 2.64 | 1.57 |
| 1917 | 26 | .68 | 2.21 | 1.40 |
| 1918 | 24 | .57 | 1.84 | 1.20 |

The rise of the average recovery from 1914 to 1916 was due largely to the facts that the dredges were for the most part working on far richer placers than in previous years, and that in 1916 a larger percentage of the placer gold came from the rich deposits of the newer districts. The decrease in the recovery per cubic yard from 1916 to 1918 is very striking. The yield per cubic yard for both the dredges and the other mines declined sharply, the proportionate output of the dredges remaining constant, and the recovery per cubic yard for both the mines other than dredges and for all the placers sank to its lowest record. It seems surprising at first sight that this condition should exist at a time when the costs have increased so much that many mines have been compelled to suspend operations and when the Alaskan placer industry has declined to about half its normal magnitude. It might be expected that at such a time the poorer mines would be closed, with a resulting increase in the average recovery. It is evident, however, that cost and not yield determines whether a mine shall continue in operation. Under adverse conditions the small-scale, high-cost operations succumb first, even though they are working on high-grade deposits. The larger plants, which for the most part are working on lower-grade deposits, continue in operation longer because they are using machinery and practicing economies that permit them to cope with the adverse conditions. Some of them are compelled to continue in operation, even at a loss, because they have rentals and other fixed charges which must be paid, machinery and other equipment which must be kept in con-

tinuous operation, or personal obligations to the community or to their employees which they can not ignore. The result is that under adverse conditions a larger proportion of the output of placer gold is derived from large expensive operations such as dredges and large hydraulic plants which are working on relatively low-grade deposits. Such was the case in Alaska in 1918, when the districts in which there are large hydraulic plants working on low-grade gravels, such as the Yentna, Nizina, Chistochina, and upper Yukon districts, alone maintained or increased their customary output. Other factors that contributed to the low average recovery for 1918 include the relatively low recovery of the dredges, which was due, in part, to the unusually large amount of frozen ground encountered by dredges in Seward Peninsula, and in part to the exhaustion of the relatively rich ground which had been dredged at Ruby in previous years, and the exhaustion of some of the richer placers, especially in the Tolovana district.

Twenty-eight gold dredges were operated in Alaska in 1918, compared with 36 in 1917. Twenty-one dredges were in Seward Peninsula, three in the Iditarod district, and one each in the Fairbanks, Circle, Yentna, and Kuskokwim districts. These dredges produced about $1,425,000 worth of gold and handled about 2,490,000 cubic yards of gravel. In 1917 the dredges handled about 3,700,000 cubic yards of gravel and recovered gold worth $2,500,000. The average recovery of gold per cubic yard was about 57 cents in 1918 and 68 cents in 1917. The gold dredges of Seward Peninsula produced gold worth $466,000 from 1,164,000 cubic yards of gravel, making an averages recovery of 40 cents a cubic yard in 1918, compared with 49 cents in 1917. The dredges of the Alaska Yukon districts produced gold worth $881,000 from 1,125,000 cubic yards of gravel, and the value of gold recovered per cubic yard was therefore about 78 cents, compared with 94 cents in 1917.

Though dredges were built for use in the Alaska Yukon as early as 1898 and at Nome in 1900, this method of placer mining did not reach a profitable stage until 1903, when two small dredges were successfully operated in Seward Peninsula. Dredging began in the Fortymile district in 1907; in the Iditarod, Birch Creek, and Fairbanks district in 1912; in the Yentna district in 1916; and in the Kuskokwim region in 1918. A new dredge was installed in the Fairbanks district in 1918 and may have begun operating late in the season. The new dredge on Candle Creek, in the Kuskokwim region, was completed in 1918 and operated for a short period. Up to the end of 1918 gold to the value of $19,035,000 had been mined by dredges. The distribution of this output by years is shown in the following table:

*Gold produced from dredge mining in Alaska, 1903–1918.*

| Year. | Number of dredges operated. | Value of gold output. | Gravel handled (cubic yards). | Value of gold recovered per cubic yard. |
|---|---|---|---|---|
| 1903 | 2 | $20,000 | | |
| 1904 | 3 | 25,000 | | |
| 1905 | 3 | 40,000 | | |
| 1906 | 3 | 120,000 | | |
| 1907 | 4 | 250,000 | | |
| 1908 | 4 | 171,000 | | |
| 1909 | 14 | 425,000 | | |
| 1910 | 18 | 800,000 | | |
| 1911 | 27 | 1,500,000 | 2,500,000 | $0.60 |
| 1912 | 38 | 2,200,000 | 3,400,000 | .65 |
| 1913 | 35 | 2,200,000 | 4,100,000 | .54 |
| 1914 | 42 | 2,350,000 | 4,450,000 | .53 |
| 1915 | 35 | 2,330,000 | 4,600,000 | .51 |
| 1916 | 34 | 2,679,000 | 3,900,000 | .69 |
| 1917 | 36 | 2,500,000 | 3,700,000 | .68 |
| 1918 | 28 | 1,425,000 | 2,490,000 | .57 |
| | | 19,035,000 | | |

## COPPER.

The copper production of Alaska in 1918 was 69,224,951 pounds, valued at $17,098,563. This is less than the production in 1917, which was 88,793,400 pounds, valued at $24,240,598. The reduction in output was due to shortage of labor and ships. During the year 17 copper mines were operated, the same number as in 1917. Of these mines, 7 are in the Ketchikan district, 5 in the Prince William Sound district, and 5 in the Chitina district.

*Output of Alaska copper mines in 1918, by districts.*

| | Mines. | Ore (tons). | Copper. | | Gold. | | Silver. | |
|---|---|---|---|---|---|---|---|---|
| | | | Quantity (pounds). | Value. | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| Ketchikan district | 7 | 21,683 | 1,372,347 | $338,970 | 1,364.54 | $28,207 | 9,745 | $9,745 |
| Chitina district [a] | 5 | 264,538 | 52,541,014 | 12,977,630 | | | 591,317 | 591,317 |
| Prince William Sound [b] | 5 | 435,826 | 15,311,590 | 3,781,963 | 3,842.32 | 79,428 | 118,329 | 118,329 |
| | 17 | 722,047 | 69,224,951 | 17,098,563 | 5,206.86 | 107,635 | 719,391 | 719,391 |

[a] Also a small amount of placer copper.
[b] Including a small amount from Cook Inlet.

The average copper content of the ores mined in 1918 was 4.5 per cent. The ores also yielded an average of $0.139 in gold and $0.932 in silver to the ton. The average yield for 1917 was 6.4 per cent of copper, $0.382 to the ton in gold, and $1.233 to the ton in silver.

*Copper produced in Alaska, 1890–1918.*

| Year. | Ore mined (tons). | Copper produced. | |
|---|---|---|---|
| | | Quantity (pounds). | Value. |
| 1880 | [a] 40,000 (1880–1904) | 3,933 | $826 |
| 1901 | | 250,000 | 40,000 |
| 1902 | | 360,000 | 41,400 |
| 1903 | | 1,200,000 | 156,000 |
| 1904 | | 2,043,586 | 275,676 |
| 1905 | 52,199 | 4,805,236 | 749,617 |
| 1906 | 105,729 | 5,871,811 | 1,133,260 |
| 1907 | 98,927 | 6,308,786 | 1,261,757 |
| 1908 | 51,509 | 4,585,362 | 605,267 |
| 1909 | 34,669 | 4,124,705 | 536,211 |
| 1910 | 39,365 | 4,241,689 | 538,695 |
| 1911 | 68,975 | 27,267,878 | 3,408,485 |
| 1912 | 93,452 | 29,230,491 | 4,823,031 |
| 1913 | 135,756 | 21,659,958 | 3,357,293 |
| 1914 | 153,605 | 21,450,628 | 2,852,934 |
| 1915 | 369,600 | 86,509,312 | 15,139,129 |
| 1916 | 617,264 | 119,854,839 | 29,484,291 |
| 1917 | 659,957 | 88,793,400 | 24,240,598 |
| 1918 | 722,047 | 69,224,951 | 17,098,563 |
| | 3,243,054 | 497,786,565 | 105,743,033 |

[a] Estimated.

The copper industry in the three developed copper fields of Alaska is described in the account of mining in those districts given on subsequent pages. The only shipment of copper ore in 1918 from outside these developed fields was a test shipment from Kamishak Bay, Cook Inlet. A copper prospect on the Alaska Peninsula is under development, and interest still continues in the copper deposits of the Talkeetna and Broad Pass districts. The copper deposits in the Alaska Range recently reported are still attracting attention, although little work has been done on them. The deposit of copper discovered in 1915 on Rainy Creek, a tributary of the South Fork of Delta River 7 miles above Miller's roadhouse, is said to be a large body of low-grade ore on which considerable crosscutting has been done. There is also a low-grade copper deposit in the gulch 1½ or 2 miles west of Paxson's roadhouse. A copper lode on McLaren River, tributary to the Susitna, is said to be 10 feet wide and of high grade. It was reported that an outfit was to be taken in on the snow in the winter of 1918–19 to prospect this deposit.

## LEAD.

The production of lead in Alaska in 1918 is estimated at 564 tons, valued at $80,088. The production in 1917, which was larger than that of any previous year, was 852 tons, valued at $146,584. Lead in Alaska is still, as in past years, derived chiefly from the concentrates of the gold mines at Juneau, but in 1918 a small amount was derived from the galena ores of the Fairbanks district. Though silver-lead

ores are found in many parts of Alaska, most of the deposits have not yet been opened on a commercial basis. The following table shows the production of lead in Alaska, so far as it can be determined from available data:

*Lead produced in Alaska, 1892–1918.*

| Year. | Quantity (tons). | Value. | Year. | Quantity (tons). | Value. |
|---|---|---|---|---|---|
| 1892 | 30 | $2,400 | 1907 | 30 | $3,180 |
| 1893 | 40 | 3,040 | 1908 | 40 | 3,360 |
| 1894 | 35 | 2,310 | 1909 | 69 | 5,934 |
| 1895 | 20 | 1,320 | 1910 | 75 | 6,600 |
| 1896 | 30 | 1,800 | 1911 | 51 | 4,590 |
| 1897 | 30 | 2,160 | 1912 | 45 | 4,050 |
| 1898 | 30 | 2,240 | 1913 | 6 | 588 |
| 1899 | 35 | 3,150 | 1914 | 28 | 1,344 |
| 1900 | 40 | 3,440 | 1915 | 437 | 41,118 |
| 1901 | 40 | 3,440 | 1916 | 820 | 113,160 |
| 1902 | 30 | 2,460 | 1917 | 852 | 146,584 |
| 1903 | 30 | 2,520 | 1918 | 564 | 80,088 |
| 1904 | 30 | 2,580 | | | |
| 1905 | 30 | 2,620 | | 3,497 | 449,496 |
| 1906 | 30 | 3,420 | | | |

## TIN.

The tin mines of Alaska produced 104½ tons of ore containing 136,000 pounds of tin, valued at $118,000, in 1918, compared with 171 tons of ore containing 200,000 pounds of tin, valued at $123,300, in 1917. The shipments from Alaska in 1918, according to the collector of customs, included 179 long tons of ore containing 232,933 pounds of tin. These shipments included ore mined in previous years. The decrease in output in 1918 was due to the fact that only one dredge was operated. The following table shows the production of tin in Alaska since mining began in 1902:

*Tin produced in Alaska, 1902–1918.*

| Year. | Quantity (tons). | | Value. | Year. | Quantity (tons). | | Value. |
|---|---|---|---|---|---|---|---|
| | Ore. | Metal. | | | Ore. | Metal. | |
| 1902 | ........ | 15 | $8,000 | 1912 | 194 | 130 | $119,600 |
| 1903 | ........ | 25 | 14,000 | 1913 | 98 | 50 | 44,103 |
| 1904 | ........ | 14 | 8,000 | 1914 | 157.5 | 104 | 66,560 |
| 1905 | ........ | 6 | 4,000 | 1915 | 167 | 102 | 78,846 |
| 1906 | ........ | 34 | 38,640 | 1916 | 232 | 139 | 121,000 |
| 1907 | ........ | 22 | 16,752 | 1917 | 171 | 100 | 123,300 |
| 1908 | ........ | 25 | 15,180 | 1918 | 104.5 | 68 | 118,000 |
| 1909 | ........ | 11 | 7,638 | | | | |
| 1910 | ........ | 10 | 8,335 | | ........ | 916 | 844,572 |
| 1911 | 92.6 | 61 | 52,798 | | | | |

Most of the tin ore mined in 1918 came from the York district, Seward Peninsula, where one tin dredge was operated. Stream tin was also obtained by sluicing at one mine in the York district. Considerable work was done on the Lost River tin lodes, but no ore was

mined. A more extended account of the tin deposits of Seward Peninsula is given elsewhere in this volume.

The tin production of the Hot Springs district is estimated at about 44 tons of cassiterite, containing about 52,400 pounds of tin. It was mostly recovered by sluicing old placer dumps.

In the Ruby district a few thousand pounds of cassiterite was recovered in placer gold mining on Short Creek. This is the second recorded tin production in the Ruby district, the only previous production being in 1916.

A little cassiterite was recovered in mining placer gold on Mason Creek, in the Gold Hill district, near Fort Gibbon. This is the first recorded recovery of tin in this district.

The discovery of placer tin has been reported from Potato and Humboldt creeks, on Seward Peninsula, and from Moran Creek, a tributary of Melozi River, where the gravels are said to contain 2½ pounds of tin and 10 cents' worth of gold to the cubic yard. Moran Creek is a few miles north of Mason Creek, where, as mentioned above, there was a small output of placer tin in 1918.

## TUNGSTEN.

The production of tungsten in Alaska in 1918 is estimated at 11½ tons of scheelite concentrates, valued at $22,000, compared with 28 tons, valued at $45,000, in 1917. The output for 1918 was derived wholly from the Fairbanks district and Seward Peninsula, except for a few pounds of scheelite that was saved at the placer mines of Bonanza Creek, near St. Michael. In the Fairbanks district one or two tungsten lode mines were operated part of the year, and it was reported that some old tailings were to be remilled.

In Seward Peninsula a few tons of scheelite was recovered at placer gold mines.

The only new development in the tungsten industry of Alaska in 1918 was the discovery of a vein of scheelite near Sitka.

## ANTIMONY.

The production of antimony from Alaskan ores, which has fallen rapidly since 1916 because of the low price of the product, almost ceased in 1918, when only 36 tons of crude ore (stibnite), valued at $1,500, was mined. This includes the output of one mine in the Fairbanks district, some ore mined in the Broad Pass district but not shipped because of lack of facilities for transportation, and a small experimental shipment from a deposit near Nome. The shipments of ores of antimony from Alaska in 1918, according to the Bureau of Foreign and Domestic Commerce, contained 11,000 pounds of metallic antimony and were valued at $184.

*Antimony produced in Alaska, 1915–1918.*

| Year. | Quantity of crude ore (tons). | Value. |
|---|---|---|
| 1915 | 833 | $74,000 |
| 1916 | 1,458 | 134,000 |
| 1917 | 165 | 28,000 |
| 1918 | 36 | 1,500 |
| | 2,492 | 237,500 |

## PLATINUM METALS.

The output of platinum, palladium, and other metals of the platinum group in Alaska in 1918 is estimated at 284 fine ounces, valued at $36,600.

Platinum was recovered from the gold placers of Dime, Bear, and Sweepstakes creeks, in the Koyuk or Dime Creek district, Seward Peninsula, in larger amounts than last year, and production was reported from Boob Creek, in the Tolstoi (Yukon) district, and from Slate Creek, in the Chistochina (Copper River) district, but in lesser quantities than in 1917. The occurrence of platinum on Albert Creek, in the Nelchina district, has been reported, but no production has been made.

One of the most interesting events of the year in connection with Alaska mining is the recovery of substantial amounts of palladium and of some platinum from the copper ore of the Salt Chuck mine, near Ketchikan.

## CHROMITE.

Chrome ore was mined at Port Chatham, Cook Inlet, on a somewhat larger scale than in 1917. A concentrating mill, tramway, wharf, and ore bins were installed in 1918. No material improvements have been made at the Red Mountain deposits, but plans for mining the ore and for transporting it to the coast have been under consideration. The chromite deposits at Port Chatham and Red Mountain were studied in detail by A. C. Gill, who has written a paper on the subject that appears elsewhere in this volume.

The discovery of chromite on Peters Creek southeast of Knik Arm and on the west fork of Chulitna River has been reported.

## MOLYBDENUM.

No molybdenum has yet been produced in Alaska, but extensive operations preparatory to mining were continued in 1918 at the molybdenite-bearing lode near Shakan, on the west coast of Prince of Wales

Island. Work was carried on also at a molybdenite prospect on the Dry Delta, which comes out at Sullivan's roadhouse, in the Tanana Valley. The deposit has not been visited by any member of the Geological Survey, and no specimens have been seen, but it is said to include closely spaced veins from a few inches to 2 feet thick occurring in a zone 800 or 900 feet wide, which has been traced for about a mile along the creek. The country rock is granite. The veins are said to carry some gold. The deposit has been developed by an adit 100 feet long cutting across the veins. A few tons of ore has been mined in prospecting, but no ore has been shipped.

## COAL.

The production of coal in Alaska in 1918 was 75,606 tons, valued at $411,850, compared with 53,955 tons, valued at $265,317, in 1917. This production was by far the largest in the history of coal mining in Alaska, being 40 per cent larger than the output for 1917, which was also greater than that of any previous year. It is believed that a substantial coal-mining industry has at last started in Alaska. The larger part of the output in 1918 came from the Matanuska field, which yielded 63,092 tons. The remainder came from eight or ten small mines in different parts of the Territory. All these mines, except those in the Matanuska and Bering River fields and at Port Graham, produced coal for local use under free-use permits. About 12 mines were operated, employing 239 men for an average period of 254 days.

In the Matanuska field the Eska Creek mines were operated regularly throughout the year by the Alaskan Engineering Commission, to supply fuel for railroad and other Government use. At the Chickaloon mine, also operated by the Alaskan Engineering Commission, the work has consisted primarily of exploration and development, and only a small amount of coal, won incidentally, has been produced. In 1918 for the first time Matanuska coal was shipped beyond Anchorage. Private operations preparatory to mining were continued by two lessees in the Matanuska field, and some coal was mined by one of them, but their mines are not yet regularly productive. A more complete account of mining in the Matanuska field is given elsewhere in this volume.

The lignite fields of the Cook Inlet and Susitna district rank next to the Matanuska coal fields in point of production for 1918. A considerable quantity of lignite that was mined near Bluff Point was shipped to towns and canneries on Cook Inlet. A lignite mine on Cache Creek in the Yentna district was operated during part of the

year to supply fuel for a gold dredge. The Little Susitna mine supplied part of the fuel for the town of Anchorage. It is reported that some coal was mined at Port Graham.

In the Nenana field no leases have yet been granted, but two small mines were opened under mining permits, and a small amount of lignite was mined for use in the construction of the railroad.

It is reported that in the Bering River field the railroad has been extended from its temporary terminus on Bering River to the mine of the Alaska Petroleum & Coal Co. in the eastern part of the field, and that small shipments of semianthracite coal were made late in the year. A lease was granted in 1918 to another company for a tract of semibituminous coal land in the western part of the field, and it is reported that extensive operations preparatory to mining are being undertaken.

In northern Alaska lignite mined near Unalaklik, on Norton Sound, was shipped to Nome and St. Michael, and lignite mined on Kobuk River was shipped to Kotzebue. It was reported that lignite would be mined on Kugruk River, Seward Peninsula, during the winter of 1918–19 for use at the placer mines on the Inmachuk.

The following table gives the estimated production of coal in Alaska since 1888. The figures for 1888 to 1896 are estimated from the best data available but are only approximate. The figures for 1897 to 1918 are based for the most part on data supplied by operators. Most of the coal mined before 1916 was lignite. There was a small production of bituminous coal from the west end of the Bering River field in 1906. The table does not include 855 tons of coal mined in the Bering River field in 1912 and 1,100 tons mined in the Matanuska field in 1913 for test by the United States Navy.

*Coal produced in Alaska, 1888 to 1918.*

| Year. | Quantity (short tons). | Value. | Year. | Quantity (short tons). | Value. |
|---|---|---|---|---|---|
| 1888-1896 | 6,000 | $84,000 | 1908 | 3,107 | 14,810 |
| 1897 | 2,000 | 28,000 | 1909 | 2,800 | 12,300 |
| 1898 | 1,000 | 14,000 | 1910 | 1,000 | 15,000 |
| 1899 | 1,200 | 16,800 | 1911 | 900 | 9,300 |
| 1900 | 1,200 | 16,800 | 1912 | 355 | 2,840 |
| 1901 | 1,300 | 15,600 | 1913 | 2,300 | 13,800 |
| 1902 | 2,212 | 19,048 | 1914 | ........ | ........ |
| 1903 | 1,447 | 9,782 | 1915 | 1,400 | 3,300 |
| 1904 | 1,694 | 7,225 | 1916 | 13,073 | 52,317 |
| 1905 | 3,774 | 13,250 | 1917 | 53,955 | 265,317 |
| 1906 | 5,541 | 17,974 | 1918 | 75,606 | 411,850 |
| 1907 | 10,139 | 53,600 | | | |
| | | | | 192,003 | 1,096,913 |

The following table shows the coal consumption of Alaska, including both local production and imports, since 1899. Most of the coal shipped to Alaska was bituminous, but a little was anthracite:

*Coal consumed in Alaska, 1899–1918, in short tons.*

| Year. | Produced in Alaska, chiefly subbituminous and lignite. | Imported from States, chiefly bituminous from Washington. | Total foreign coal, chiefly bituminous from British Columbia. | Total coal consumed. |
|---|---|---|---|---|
| 1899 | 1,200 | 10,000 | [a] 50,120 | 61,320 |
| 1900 | 1,200 | 15,048 | [a] 56,623 | 72,871 |
| 1901 | 1,300 | 24,000 | [a] 77,674 | 102,974 |
| 1902 | 2,212 | 40,000 | [a] 68,363 | 110,575 |
| 1903 | 1,447 | 64,626 | [a] 60,605 | 126,678 |
| 1904 | 1,694 | 36,689 | [a] 76,815 | 115,198 |
| 1905 | 3,774 | 67,713 | [a] 72,612 | 114,099 |
| 1906 | 5,541 | 69,493 | [a] 47,590 | 122,624 |
| 1907 | 10,139 | 46,246 | [a] 93,262 | 149,647 |
| 1908 | 3,107 | 23,893 | [a] 86,404 | 113,404 |
| 1909 | 2,800 | 33,112 | 69,046 | 104,958 |
| 1910 | 1,000 | 32,098 | 58,420 | 91,518 |
| 1911 | 900 | 32,255 | 61,845 | 95,000 |
| 1912 | 355 | 27,767 | 68,316 | 96,438 |
| 1913 | 2,300 | 69,066 | 56,430 | 127,796 |
| 1914 | ........ | 41,509 | 46,153 | 87,662 |
| 1915 | 1,400 | 46,329 | 29,457 | 77,186 |
| 1916 | 13,073 | 44,934 | 53,672 | 111,679 |
| 1917 | 53,955 | 58,116 | 56,589 | 168,660 |
| 1918 | 75,606 | 51,520 | 37,986 | 165,112 |
| | 183,003 | 834,414 | 1,227,982 | 2,245,399 |

[a] By fiscal year ending June 30.

## PETROLEUM.

The petroleum produced in Alaska is still derived wholly from the single patented claim in the Katalla field. The old wells on this claim and the refinery were operated as usual, and two new productive wells were drilled. The total production in 1918 was somewhat larger than in 1917.

There has been a revival of interest in the potential Alaskan oil fields during the year in anticipation of the expected passage of a law providing for the leasing of the Alaskan oil lands. It is reported that investigations of the supposed oil lands on the Alaska Peninsula were made during the summer of 1918. No legal provision has yet been made for the leasing, and the Alaskan oil lands are still withdrawn from entry. There was some drilling for oil in the crystalline rocks near Cape Nome in the summer of 1918, but the results were unfavorable, as was to be expected. At Seward some interest was aroused over the discovery of inflammable gas issuing from the mud and water at several localities in the swamps along the railroad. The rocks near these localities, as described by Grant,[1] are slates that have been metamorphosed and folded to a degree which makes it impossible for accumulations of oil or gas to be retained in them.

[1] Grant, U. S., Geology and mineral resources of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. 587, pp. 211–212, 217, 1915.

The consumption of petroleum in Alaska is indicated approximately by the imports, which are shown in the following table:

*Petroleum products shipped to Alaska from other parts of the United States, 1905–1918, in gallons.*[a]

| Year. | Oil used for fuel, including crude oil, gas oil, residuum, etc. | Gasoline, including all lighter products of distillation. | Illuminating oil. | Lubricating oil. |
|---|---|---|---|---|
| 1905 | 2,715,974 | 713,496 | 627,391 | 83,319 |
| 1906 | 2,688,940 | 580,978 | 568,033 | 83,992 |
| 1907 | 9,104,300 | 636,881 | 510,145 | 100,145 |
| 1908 | 11,891,375 | 939,424 | 566,598 | 94,542 |
| 1909 | 14,119,102 | 746,930 | 531,727 | 85,687 |
| 1910 | 19,143,091 | 788,154 | 620,972 | 104,512 |
| 1911 | 20,878,843 | 1,238,865 | 423,750 | 100,141 |
| 1912 | 15,523,555 | 2,736,739 | 672,176 | 154,565 |
| 1913 | 15,682,412 | 1,735,658 | 661,656 | 150,918 |
| 1914 | 18,601,384 | 2,878,723 | 731,146 | 191,876 |
| 1915 | 16,910,012 | 2,413,962 | 513,075 | 271,981 |
| 1916 | 23,555,811 | 2,844,801 | 732,369 | 373,046 |
| 1917 | 23,971,114 | 3,256,870 | 750,238 | 465,693 |
| 1918 | 24,379,566 | 1,086,852 | 382,186 | 362,413 |
| | 219,165,479 | 22,598,333 | 8,291,462 | 2,622,830 |

[a] Compiled from Monthly Summary of Foreign Commerce of the United States, 1905 to 1918, Bureau of Foreign and Domestic Commerce.

## STRUCTURAL MATERIAL.

Marble was produced from one quarry in southeastern Alaska but in a somewhat lesser amount than in 1917. The production of gypsum decreased, as the gypsum mine on Chichagof Island was not operated after March, when the mine buildings were burned. A small quantity of agricultural lime was dug from the marl deposits near Anchorage. There was no production in 1918 of bricks, quicklime, graphite, or barite.

## REVIEW BY DISTRICTS.

The following review summarizes briefly the principal developments in all the districts. Many of the districts were not visited by members of the Geological Survey in 1918, and some operators failed to make reports, so that the information at hand about mining in some of the districts is incomplete and scanty. The space here devoted to any district is therefore not necessarily an indication of its relative importance. The arrangement of the discussion is geographic, from south to north.

### SOUTHEASTERN ALASKA.

The mineral production of southeastern Alaska in 1918 was derived from 6 gold-lode mines, 7 copper mines, several small placer mines, 1 gypsum mine, and 1 marble quarry. The value of the mineral production fell from $5,407,902 in 1917 to $3,825,495 in 1918. The largest mining operations were, as in previous years, at the gold

mines in the Juneau district. All the productive copper mining was in the Ketchikan district. Placer mining was limited to the Porcupine district and to small beach operations at Lituya Bay and possibly at Yakataga.

*Mineral production of southeastern Alaska, 1918.*

| | Ore mined (tons). | Gold. | | Silver. | | Copper. | | Lead. | | Palladium, marble, gypsum, etc. (value). |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Quantity (fine oz.). | Value. | Quantity (fine oz.). | Value. | Quantity (lbs.). | Value. | Quantity (lbs.). | Value. | |
| Gold-lode mines | 2,085,915 | 152,755 | $3,157,732 | 88,053 | $88,053 | ........ | ........ | 1,121,894 | $79,654 | ........ |
| Copper mines | 21,683 | 1,365 | 28,207 | 9,745 | 9,745 | 1,372,347 | $338,970 | ........ | ........ | (a) |
| Placer mines | ........ | 484 | 10,000 | 80 | 80 | ........ | ........ | ........ | ........ | ........ |
| | ........ | 154,604 | 3,195,939 | 97,878 | 97,878 | 1,372,347 | 338,970 | 1,121,894 | 79,654 | $113,054 |

[a] Some palladium and platinum were derived from copper ore, but the amount and value are not given, as the output came from a single mine.

In the Ketchikan district the It, Jumbo, Rush & Brown, Mamie, Salt Chuck, and Rich Hill copper mines were operated, each for at least part of the year, producing about 1,372,347 pounds of copper and $37,952 worth of gold and silver. All the mines of the Ketchikan district were affected by shortage of labor and ships. The Dunton gold mine, at Hollis, was operated on the customary scale. The mill was run for the equivalent of about 150 days, and the mine was kept pumped out for the entire year. No important new developments were undertaken. Shipments of ore were made from the It and Mamie mines, a considerable amount of development work being done at the It mine, but operations at both mines were suspended before the end of the year. The Rush & Brown mine was operated through the year and made a somewhat larger production than in 1917. The Jumbo mine was operated most of the year but was handicapped by poor shipping facilities. The Salt Chuck mine was in active operation throughout the year. A 12,000-foot drift was being driven, and the mill was operated whenever water power was available. Several shipments of concentrates were made, which yielded a considerable amount of palladium and some platinum in addition to the copper, gold, and silver for which the mine has been worked in previous years. The Rich Hill mine made shipments of crude ore. A shaft and drifts were extended 20 feet and 42 feet, respectively. The Chacon prospect was stripped for about 1,000 feet along the strike, and a shaft was sunk on it to a depth of 60 feet, but the ore was found to be irregular and work was discontinued. At the Independence prospect about 300 feet of diamond drilling was done. At the Westlake mine the drifts were extended and experiments were made in the treatment of the ore.

In the Wrangell district there was no productive mining in 1918. A considerable amount of work preparatory to mining was done at the molybdenite deposit near Shakan, where about 350 feet of adit was driven. A wharf and a tramway leading from the wharf to the mine were built. Preparations are being made for producing ferromolybdenum from this ore at Treadwell. The marble quarry at Tokeen was operated, but at a reduced capacity because of the shortage of labor and of ships.

In the Juneau district the Alaska Gastineau, Alaska Juneau, and Ready Bullion mines were operated throughout the year but at a reduced capacity because of scarcity of labor, and the Peterson mine was operated during the summer as usual. Work preparatory to mining was undertaken at several nonproducing mines.

At the Alaska Gastineau (Perseverance mine) a scarcity of labor was felt early in the year, and in January the mill was operated on a basis of 6,000 tons a day. At this time there were 700 men on the pay roll. This number was gradually decreased until in October the total number of men on the pay roll was only 350. From about April 1 to November 30 the mill was operated for only one 8-hour shift a day, milling about 3,000 tons daily. Late in the year the supply of labor became more ample, but the total production of the mine throughout the year was less than half what it would have been under normal operating conditions. Because of the scarcity of skilled miners no new development work or prospecting was undertaken.

The Alaska Juneau mine and mill were operated throughout the year. The principal development work consisted of the construction of a stope above the Gold Creek tunnel level lying west of a large stope prepared above this level prior to 1917. All underground work was limited by the amount of labor available. The Alaska Juneau mill as originally constructed contained many experimental features that have turned out to be unsuitable for the ore, and the milling operations during 1918 have proved that the mill as it now stands has only half of its promised capacity. Plans are under way for altering the mill so as to reduce its operating costs and to bring its capacity up to 8,000 tons of ore a day, as was originally expected. During part of the year the 50-stamp pilot mill was operated instead of the new ball mills.

At the Ready Bullion mine during 1918 the stoping and other work necessary to supply waste for filling the worked-out portions of the mine below the 1,050-foot level were completed, and at the end of the year the work of filling with waste was being carried on actively. Pending the completion of this work, and also because of shortage of labor, the mill did not run at its normal capacity till September. Amalgamation has been discontinued in the mill, and the returns

are obtained from the iron concentrates, which are treated at the cyanide plant. The shaft has been sunk to a point somewhat below the 2,800-foot level, and a crosscut has been started. The small amount of work done toward the end of the year on the 2,800-foot level was in ore of normal value.

The Alaska Treadwell and Alaska Mexican mines and mills did not operate in 1918, but some gold was cleaned up around the old stamp batteries.

The Peterson mine, at Pearl Harbor, was operated on the customary scale throughout the summer.

The Ebner mine employed a small crew of men on development work throughout the year. At the Pekovich mine the driving of an adit has continued since May 1. At the Alaska Endicott mine an adit was driven for 26 feet, and 250 feet of drifts were driven on the vein. Some work was done during the summer by the Alaska Peerless Mining Co. at Windham Bay and by the Alaska Copper Co. at Sumdum. The Jualin, Kensington, Eagle River, Daisy Bell, and Auk Bay mines were idle throughout the year.

In the Sitka district the Chichagoff mine was operated throughout the year and made an unusually large production. Extensive developments were under way at the Hirst-Chichagoff property. Veins of tungsten ore (scheelite) have been discovered near Sitka.

The gypsum mine on Chichagoff Island made shipments during the early part of the year but has been shut down since March because of a fire.

## COPPER RIVER REGION.

The productive mines of the Copper River region in 1918 included five copper mines and one gold lode mine in the Chitina Valley and about 22 gold placer mines in the Nizina, Chistochina, and Nelchina districts. The mineral output of the region included copper, silver, gold, and platinum having a total value of $13,811,135.

The Kennecott-Bonanza and Jumbo copper mines were in continuous operation except when the Bonanza mine was shut down for two weeks because the tram had been carried away by snowslides. Shipments from the Jumbo mine were curtailed for six weeks from the same cause. The production of both mines was reduced throughout the year by scarcity of labor, the mines being operated from March 1 to October 1 with approximately a 75 per cent crew. In October the crew was increased to about 90 per cent of the normal capacity of the mines. At the Jumbo mine a new double-compartment incline was begun and was extended to the 500 level. At the Bonanza mine the double-compartment incline was extended to the 800 level. The 700 level was the only new level opened during the year, but a large amount of development work

was done on the 600 level. Some work was done preparatory to increasing the capacity of the Bonanza tramway from 500 to 800 tons and of the Jumbo tramway from 450 to 650 tons a day. At the mill only minor changes and additions were made. The addition to the ammonia leaching plant was not entirely completed during the year, but it was so far advanced that the plant is now capable of treating all tailings coming from the concentrating mill. Material treated in the leaching plant for the year will assay approximately 0.85 per cent of copper in the form of carbonates. An extraction of about 75 per cent will be made, with a loss of a half pound of ammonia to the ton of material leached. The Erie mine was operated until August 10, when it was shut down for lack of labor.

The Mother Lode mine made shipments of ore during the winter. Developments at the Mother Lode mine include the continuation of the sinking of the shaft and the driving and development of the Rhodes level by about 2,500 feet of drifting and tunneling.

The Nugget Creek mine of the Alaska Copper Corporation was operated during part of the year, and some ore and concentrates were shipped from it. A concentrating plant with jaw crushers, jigs, and Wilfley and Card tables was installed in 1918. The ore and concentrates are hauled to the railroad at Strelna in motor trucks.

The Westover mine shipped some ore to the Ladysmith smelter in the winter of 1917–18. On the Green group, on the east side of McCarthy Creek, about 500 feet of tunnel was driven.

A lead prospect discovered in 1916 near the head of Chitina River, about 80 miles from McCarthy, attracted some attention, but no work was done on it in 1918. The deposit consists of lenses of lead-zinc ore in crystalline limestone.

The gold mine of the North Midas Copper Co., on Kuskulana River, was operated during part of the year, and a carload of ore from this mine was shipped during the winter. A mill and cyanide plant were installed during the summer and were reported to be in operation in November. The vein, which is from 1½ inches to 6 feet wide and averages 2 or 3 feet, is made up of quartz with pyrite and some chalcopyrite. A few stains of copper carbonate were seen. The ore contains a fraction of 1 per cent of copper, but is chiefly valuable for gold and silver. The vein, which strikes northeast and dips 45°–55° SE., cuts a mass of fine-grained epidotized porphyry that lies between coarse porphyry and limestone. Ore has hitherto been mined from tunnel No. 4. Tunnel No. 5, which will be the working tunnel, cuts the vein 570 feet in and 120 feet vertically below No. 4. The mill includes Blake and Wheeling crushers, a Denver engineering ball mill, a Dorr thickener, mechanical agitators, and an Oliver filter. The capacity is 25 tons a day. The cyanide plant uses an all-slime process with precipitation by zinc shavings.

The power plant includes a 14-inch to 8-inch pipe line 2,200 feet long, with 200-foot head and a 60-horsepower Castle wheel. A Roebling tram 4,600 feet long, with a 1,000-foot drop, 500-pound automatic loading and discharging buckets, and a capacity of 5 tons an hour will be installed.

The Nizina gold placers are still being worked on a large scale. Gold worth about $135,000 was recovered by seven mines operating in the summer and four mines operating in the winter. About 70 men were employed in the summer and 7 men in the winter. Some placer copper was recovered.

The Chistochina placer mines are said to have had a very successful season and to have produced gold worth $100,000 from the summer operations of about 14 mines employing about 50 men. A small amount of platinum was recovered.

## PRINCE WILLIAM SOUND.

The value of the minerals produced on Prince William Sound in 1918 was $3,990,914, compared with $4,667,929 in 1917. This amount is the value of the product at five copper mines and four gold mines.

*Mineral production of Prince William Sound, 1918.*

| | Ore (tons). | Gold. | | Silver. | | Copper. | |
|---|---|---|---|---|---|---|---|
| | | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. | Quantity (pounds). | Value. |
| Copper mines | 434,825 | 3,842 | $79,421 | 118,318 | $118,318 | 15,311.216 | $3,781,870 |
| Gold mines | 415 | 542 | 11,202 | 103 | 103 | | |
| | 436,240 | 4,384 | 90,623 | 118,421 | 118,421 | 15,311.216 | 3,781,870 |

By far the larger part of the copper output of Prince William Sound in 1918 came, as in previous years, from the Beatson-Bonanza mine, which, because of the increased capacity of the mechanical equipment, was operated throughout the year on a larger scale than ever before, although the supply of labor from March 1 to November 1 did not average more than 70 per cent of the normal capacity of the mine. The developments for the year include the completion of the new power plant, the extension of the double hoisting compartment vertical shaft to a depth of 300 feet below the main level, the enlargement of the mill to a capacity of 1,500 tons a day, and the increase of the capacity of the dock bunkers to 5,500 tons. A 500-ton pocket was cut and completed on the 200-foot level, and the development of that level was started.

The Ellamar mine was operated throughout the year but at a reduced capacity, owing to the shortage of labor and shipping. Underground developments in 1918 included 200 feet of drifting. No important changes were made.

The Fidalgo or Schlosser mine, on Fidalgo Bay, was operated throughout the year on about the same scale as in 1917. A lower tunnel was started, a small compressor plant was installed, and about 690 linear feet of new work was done in the ore zone.

At the Midas mine, near Valdez, mining was suspended during the winter, but a small force was retained to carry on development operations. In April the force was again enlarged, and regular mining was carried on until September, when all the work except diamond drilling was indefinitely suspended because it was impossible to ship ore.

At the Blackbird group of the Latouche Copper Mining Co., on Latouche Island, operations were much hampered by shortage of men, power, and cargo space. Early in the year some ore was shipped, and later ore was mined but not shipped. The property has passed into the hands of the Ladysmith Smelting Corporation, which is proceeding with the development. At the property of the Threeman Mining Co., on Landlocked Bay, some ore was mined but not shipped. At the Fidalgo or Mackintosh mine of the Fidalgo Mining Co. underground developments were continued, but no ore was shipped.

Gold mining on Prince William Sound was confined to the operations of four mines in the Valdez and Port Wells districts, which yielded only a small production. Some ore was mined and milled at the Gold King mine, but no extensive developments were undertaken. It is reported that the Cliff mine was operated by three men under a lease for a short time. The Alaska Homestake mine, in the Port Wells district, was leased to the Alaska Free Gold Co., of Valdez. The mine was operated for part of the year, a compressor and a 7-foot Lane Chilean mill obtained from the Granite mine were installed, and one small mill run was made. The Big Four property, on Mineral Creek, was operated in a small way, and it was reported that a stamp mill was being installed. At the Capitol Hill mine, on the north shore of Barry Arm, a 40-foot tunnel was driven in ore carrying gold, silver, and copper, but no ore was shipped. At the Q. & Q. property, on College Fiord, a 150-foot tunnel was driven in 1918.

### KENAI PENINSULA.

The mineral production of Kenai Peninsula in 1918 included about $8,000 in placer gold, $6,016 in lode gold, a small amount of silver obtained incidentally to the mining of the gold, a considerable amount

of chromite, which was mined at Port Chatham, and some lignite mined at Bluff Point and possibly at Port Graham.

There was very little activity in lode-gold mining and no extensive developments are reported. Four small gold mines produced gold worth $6,016 and silver worth $181 from 207 tons of ore. A quartz lode carrying free gold discovered on Nuka Bay in 1917 has attracted some attention, and it is reported that this lode was being developed in 1918.

Placer mining continued on a small scale at several localities in Kenai Peninsula, and it is estimated that gold worth about $8,000 was thus produced.

The chromite mine at Port Chatham was operated throughout the season, making a somewhat larger production than in 1917. The developments for the year included the construction of a wharf and tram road and the installation of a stamp mill. Prospecting for chrome ore continued in the Port Chatham and Red Mountain areas. The discovery of chrome ore on Peters Creek, southeast of Knik Arm, is reported. The chromite deposits of Kenai Peninsula are described by Prof. Gill in another chapter of this report.

Some work was done at a graphite prospect at Seldovia.

### MATANUSKA, COOK INLET, AND SUSITNA COAL FIELDS.

The coal mines of the Matanuska field supplied the larger part of the Alaskan coal output in 1918, yielding about 63,092 tons of coal, valued at $368,465. A more complete account of mining in the Matanuska field is given by Mr. Chapin in another chapter of this volume. A lignite mine on Little Susitna River was operated much of the year and produced fuel that was shipped to Anchorage. The mine at Bluff Point and possibly that at Port Graham supplied lignite to the towns and canneries on Cook Inlet. Lignite was mined on Cache Creek, in the Yentna district, to furnish power for a gold dredge. It is reported that lignite has been discovered at several localities along the route of the railroad as far north as Broad Pass. It is also reported that large coal or lignite beds have been discovered on Hyas River, which is tributary to Skwentna River, and at other localities on streams tributary to the Yentna and Skwentna. A further statement on coal mining is given on pages 24–25.

### WILLOW CREEK DISTRICT.

The gold-lode mines of the Willow Creek district report a very successful season. The Gold Bullion, Gold Cord, Alaska Free Gold, Mabel, and Talkeetna mines were operated, producing an aggregate amount of gold worth $269,624 and silver worth $724 from 7,976 tons of ore. Development work was carried on and a small mill erected

at the War Baby mine, on Craigie Creek. A more complete account of mining in the Willow Creek district is given by Mr. Chapin elsewhere in this volume.

### YENTNA DISTRICT.

The Cache Creek placers, in the Yentna district, are estimated to have produced in 1918 gold worth $150,000 from the operation of 16 mines and one dredge. About 120 men were employed in productive mining. There were also a few outfits doing dead work. Mining was curtailed during part of the season by shortage of water, but on the whole a favorable season is reported. The dredge on Cache Creek operated successfully in 1918, but it was reported that the dredge would not operate during part of the season of 1919, while electric power was being installed on it. Lignite was mined in 1918 for use in the operation of the dredge.

### UPPER SUSITNA REGION.

The only known mineral production in the upper Susitna region in 1918 was a small amount of placer gold in the Valdez Creek district and some antimony ore (stibnite) that was mined but not shipped in the Broad Pass district. Interest in the gold, copper, and antimony lodes of the Kashwitna, Iron Creek, upper Chulitna, and Broad Pass districts still continues, but active work on them has for the most part been suspended pending the extension of the railroad and in the hope of cheaper and more abundant labor and supplies. The discovery of beds of lignite has been reported from several localities along the railroad route.

### SOUTHWESTERN ALASKA.

There was very little mining activity in southwestern Alaska in 1918. A little placer gold was recovered from the beaches of Kodiak Island, from a creek near Katmai, and from Portage Creek, tributary to Clark Lake. Development work was continued in a small way at the McNeil property or Reward-Ridgway group near Kamishak Bay, and a test shipment of copper ore was made. Work was continued at the copper prospect of the Shelikof Mining Co., near Kukak Bay, on the Alaska Peninsula, but no ore has been shipped. It is reported that operations preparatory to mining were continued at some of the sulphur deposits of the Aleutian Islands and that a test shipment of sulphur from Akun Island was made. A deposit of iron ore (magnetite) is said to have been found at Tuxedni Bay, on the west shore of Cook Inlet.

## YUKON BASIN.

### GENERAL FEATURES.

The value of the mineral output of the Alaska part of the Yukon Valley in 1918 was $4,390,237, compared with $6,747,835 in 1917. The output was derived by substances and by methods of mining as follows:

*Mineral production of the Yukon Basin, Alaska, 1918.*

| | Placer mines. | | Lode mines. | | Total. | |
|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| Gold........fine ounces.. | 206,271 | $4,264,000 | 1,294 | $26,750 | 207,565 | $4,290,750 |
| Silver........do.... | 28,831 | 28,831 | 616 | 616 | 29,447 | 29,447 |
| Tin, metal........pounds.. | 56,000 | 48,500 | | | 56,000 | 48,500 |
| Tungsten, antimony, and lead........ | | | | 15,915 | | 15,915 |
| Coal........short tons.. | | | 969 | 4,325 | 969 | 4,325 |
| Platinum........ | | 1,300 | | | | 1,300 |
| | | 4,342,631 | | 47,606 | | 4,390,237 |

Of the products listed above the lode gold and silver and the tungsten, antimony, and lead were mined in the Fairbanks district. The tin was obtained chiefly from gold placers in the Hot Springs district, though small amounts were recovered in the gold placers of the Gold Hill and Ruby districts. The coal was mined in the Nenana field and comprises the first shipments from that field. Platinum was recovered in mining placer gold in the Tolstoi district. The derivation of the placer gold and silver will be indicated below.

Since mining began in 1886 the Alaska Yukon has produced minerals to the value of $127,829,607, of which $126,205,776 was obtained from the placers, and of this $125,447,000 was placer gold. The derivation of this output by substances and by kinds of mines is shown in the following table:

*Total mineral production of the Yukon basin, Alaska, 1886–1918.*

| | Placer mines. | | Lode mines. | | All mines. | |
|---|---|---|---|---|---|---|
| | Quantity. | Value. | Quantity. | Value. | Quantity. | Value. |
| Gold........fine ounces.. | 6,068,578.51 | $125,447,000 | 57,751.81 | $1,193,836 | 6,126,330.32 | $126,640,836 |
| Silver........do.... | 1,051,081 | 620,526 | 13,376 | 8,498 | 1,064,457 | 629,024 |
| Antimony (crude ore)tons.. | | | 2,251 | 218,500 | 2,251 | 218,500 |
| Tin (metal).......pounds.. | 280,400 | 135,150 | | | 280,400 | 135,150 |
| Tungsten (crude ore) tons.. | | | | 107,000 | | 107,000 |
| Coal........short tons.. | | | 10,969 | 94,325 | 10,969 | 94,325 |
| Platinum (crude)..ounces.. | 45 | 3,100 | | | 45 | 3,100 |
| Lead........tons.. | | | 10 | 1,672 | 10 | 1,672 |
| | | 126,205,776 | | 1,623,831 | | 127,829,607 |

The value of the gold produced by the placer mines of the Alaska Yukon districts in 1918 is estimated to have been $4,264,000, com-

pared with $6,583,000 in 1917. The production in 1918 is the smallest recorded since 1904. The decrease was general throughout the region, except in some of the upper Yukon districts, and was due to the high cost of operating, the scarcity of labor, and a general hesitation to undertake ventures in the face of future uncertainties. About 355 placer mines were operated in the summer of 1918, giving employment to about 1,965 men, and about 121 placer mines were operated in the winter of 1917–18, employing about 490 men.

*Estimated value of gold produced from principal placers of Yukon basin, 1918.*

| | | | |
|---|---|---|---|
| Iditarod | $1, 240, 000 | Marshall | $150, 000 |
| Tolovana | 875, 000 | Koyukuk | 150, 000 |
| Fairbanks | 800, 000 | Innoko and Tolstoi | 120, 000 |
| Ruby | 400, 000 | All others | 204, 000 |
| Circle | 175, 000 | | |
| Hot Springs | 150, 000 | | 4, 264, 000 |

The placer mines of the Yukon region in Alaska are estimated to have produced gold and silver to the value of $125,447,000 and $620,526, respectively, since mining began in 1886. The derivation of this output by districts is shown in the following table. The production of the several districts by years will be given in the descriptions of the districts.

*Placer gold and silver produced in Yukon basin, Alaska, by districts.*

| District. | Period. | Gold. | | Silver. | |
|---|---|---|---|---|---|
| | | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| Fairbanks | 1903–1918 | 3, 357, 225. 00 | $69, 400, 000 | 626, 211 | $348, 290 |
| Iditarod | 1910–1918 | 830, 115. 00 | 17, 160, 000 | 116, 020 | 73, 532 |
| Circle | 1894–1918 | 307, 906. 87 | 6, 365, 000 | 74, 838 | 45, 980 |
| Fortymile | 1886–1918 | 304, 278. 73 | 6, 290, 000 | 48, 058 | 33, 532 |
| Hot Springs | 1902–1918 | 291, 623. 86 | 6, 028, 400 | 46, 150 | 27, 963 |
| Ruby | 1907–1918 | 232, 006. 51 | 4, 796, 000 | 32, 278 | 21, 593 |
| Koyukuk | 1900–1918 | 210, 218. 39 | 4, 345, 600 | 29, 884 | 18, 263 |
| Tolovana | 1915–1918 | 135, 691. 87 | 2, 805, 000 | 15, 624 | 13, 020 |
| Innoko and Tolstoi | 1907–1918 | 117, 793. 12 | 2, 435, 000 | 12, 712 | 7, 612 |
| Salchaket-Tenderfoot | 1905–1918 | 82, 607. 73 | 1, 706, 000 | 16, 864 | 9, 923 |
| Rampart | 1896–1918 | 72, 901. 11 | 1, 507, 000 | 11, 167 | 6, 818 |
| Marshall | 1914–1918 | 42, 811. 86 | 885, 000 | 6, 176 | 4, 899 |
| Chisana | 1913–1918 | 26, 364. 38 | 545, 000 | 6, 282 | 3, 645 |
| Kantishna | 1903–1918 | 20, 559. 36 | 425, 000 | 3, 226 | 2, 024 |
| Eagle | 1908–1918 | 13, 157. 99 | 272, 000 | 2, 085 | 1, 278 |
| Bonnifield | 1903–1918 | 11, 803. 49 | 244, 000 | 1, 858 | 1, 110 |
| Indian River and Gold Hill | 1911–1918 | 6, 071. 07 | 125, 500 | 862 | 520 |
| Chandalar | 1906–1918 | 5, 442. 18 | 112, 500 | 786 | 524 |
| | | 6, 068, 578. 51 | 125, 447, 000 | 1, 051, 081 | 620, 526 |

## FAIRBANKS DISTRICT.

The mineral production of the Fairbanks district in 1918 included placer gold worth $800,000, lode gold worth $26,750, placer silver worth $5,708, lode silver worth $616, and lead, tungsten, and antimony worth $15,915. The total value was $848,989.

The production of the placer mines was about $510,000 less than in 1917. A large number of operators did not undertake any work, and others shut down during the summer. It is estimated that about 68 mines, employing about 390 men, were operated for at least part of the summer of 1918, and about 35 mines, employing about 170 men, in the winter of 1917–18. The old dredge of the Fairbanks Gold Mining Co., on claim "No. 6 above," Fairbanks Creek, was operated throughout the season. A Bucyrus dredge, with a capacity of 3,000 yards per day, equipped with 4-foot buckets, a Neil jig, and two 120-horsepower Diesel engines, which was installed by the same company on "No. 1 below," Fairbanks Creek, was completed, and was expected to begin operations late in the summer. Some interest was aroused by the discovery of pay gravel in shallow bench deposits on Ophir Creek, tributary to Beaver Creek. Preparations were being made late in the summer to determine the extent of the pay gravel. No authentic information as to what may have been found has been received since the summer.

The aggregate value of the mineral output of the Fairbanks district up to the close of 1918 is $71,266,680. Much the larger part of this amount represents the value of the placer gold, the production of which is shown by years in the subjoined table. In addition to the actual production of the district, about $1,000,000 worth of gold mined in tributary areas passes through Fairbanks each year.

*Placer gold and silver produced in the Fairbanks district, 1903–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1903 | 1,935.00 | $40,000 | 348 | $188 |
| 1904 | 29,025.00 | 600,000 | 5,225 | 2,821 |
| 1905 | 290,250.00 | 6,000,000 | 52,245 | 28,212 |
| 1906 | 435,375.00 | 9,000,000 | 78,367 | 42,318 |
| 1907 | 387,000.00 | 8,000,000 | 69,660 | 37,616 |
| 1908 | 445,050.00 | 9,200,000 | 79,909 | 43,151 |
| 1909 | 466,818.75 | 9,650,000 | 84,027 | 45,375 |
| 1910 | 295,087.50 | 6,100,000 | 53,116 | 28,683 |
| 1911 | 217,687.50 | 4,500,000 | 52,245 | 27,690 |
| 1912 | 200,756.25 | 4,150.000 | 48,182 | 29,632 |
| 1913 | 159,637.50 | 3,300,000 | 20,274 | 12,245 |
| 1914 | 120,937.50 | 2,500,000 | 29,024 | 16,050 |
| 1915 | 118,518.75 | 2,450,000 | 28,444 | 14,421 |
| 1916 | 87,075.00 | 1,800,000 | 11,058 | 7,276 |
| 1917 | 63,371.25 | 1,310,000 | 8,379 | 6,904 |
| 1918 | 38,700.00 | 800,000 | 5,708 | 5,708 |
| | 3,357,225.00 | 69,400,000 | 626,211 | 348,290 |

The available information as to the source of the gold by creeks is not very accurate. An attempt has been made in the following table, however, to distribute the total placer-gold production of the Fairbanks district by the creeks on which the mines are located:

*Approximate distribution of gold produced in Fairbanks district, 1903–1918.*

| | |
|---|---|
| Cleary Creek and tributaries | $22,980,000 |
| Goldstream Creek and tributaries | 14,080,000 |
| Ester Creek and tributaries | 11,280,000 |
| Dome Creek and tributaries | 8,020,000 |
| Fairbanks Creek and tributaries | 7,500,000 |
| Vault Creek and tributaries | 2,660,000 |
| Little Eldorado Creek | 2,220,000 |
| All other creeks | 660,000 |
| | 69,400,000 |

Lode mining in the Fairbanks district included the operation of six small gold mines, whose combined output of gold and silver, including that of three additional prospects, or mines that were not in regular operation, was worth about $27,376, compared with $49,557 in 1917. A little lead was also produced in 1918, and there were small outputs from one antimony mine and one or two tungsten mines. The following table shows the production of gold and silver from the lode mines of the Fairbanks district since lode mining began in 1910:

*Lode gold and silver produced in the Fairbanks district, 1910–1918.*

| Year. | Crude ore (short tons). | Gold. | | Silver. | |
|---|---|---|---|---|---|
| | | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1910 | 148 | 841.19 | $17,389 | 106 | $57 |
| 1911 | 875 | 3,103.02 | 64,145 | 582 | 308 |
| 1912 | 4,708 | 9,416.54 | 194,657 | 1,578 | 971 |
| 1913 | 12,237 | 16,904.98 | 349,457 | 4,124 | 2,491 |
| 1914 | 6,526 | 10,904.75 | 225,421 | 2,209 | 1,222 |
| 1915 | 5,845 | 10,534.91 | 217,776 | 1,796 | 910 |
| 1916 | 1,111 | 1,904.81 | 39,376 | 140 | 92 |
| 1917 | 1,200 | 2,311.38 | 47,781 | 2,217 | 1,826 |
| 1918 | 1,035 | 1,294.04 | 26,750 | 616 | 616 |
| | 33,685 | 57,215.62 | 1,182,752 | 13,368 | 8,493 |

On Fairbanks Creek productive mining was carried on at the Mizpah, Crites & Feldman, and Rob-Rye mines. At the Mizpah mine the workings include an inclined shaft 200 feet deep and drifts 100 feet long. The mine is equipped with a 5-stamp Allis-Chalmers mill, which was operated in 1918 whenever a sufficient supply of ore accumulated. The driving of an adit on the Gilmore & Stevens property, which will cut the Mizpah lode near the present lower workings, was continued and was nearing completion in 1918. At the Crites & Feldman mine the driving of the upper tunnel on the Hi Yu claim was continued, and ore was mined and milled during much of the year. At the Rob-Rye mine some ore was hoisted and milled early in the year, but operations were suspended because of water.

The David mine, on Skoogy Gulch, was operated by Roth & Maddocks. A 250-foot adit was driven, a Johnson vanner was added to the standard 2-stamp mill, and ore was mined and milled. Work at the North Star claim, Skoogy Gulch, consisted of the driving of an adit intended to cut a ledge exposed on the top of the hill.

At the Creighton & Heilig mine, on Little Eldorado Dome, work was continued at a shaft sunk in 1912 on the Rose claim, and ore was being mined and milled.

On Eva Creek the Smith & McGlone and Tyndall & Finn mines and the St. Paul mill were operated during part of the year. The Smith & McGlone mine, on the Billy Sunday (formerly Leah fraction) claim, was operated from May 1 to October 1, and two mill runs were made. The Tyndall & Finn mine, on the Bondholder group, was operated during part of the year, and some ore was milled. At the St. Paul mine 150 feet of tunnel was driven and some ore was mined but not milled. The St. Paul mill was operated on ore for Smith & McGlone and Tyndall & Finn. At the Ohio claim of John Rogach, at the head of Spruce Creek, a small amount of ore was mined and milled, but the work was more in the nature of prospecting than of regular mining. The Ohio claim is developed by a vertical shaft 25 feet deep and 25 feet of drift.

Small amounts of lead-silver ore from the Fairbanks district were treated in 1918 at the experiment station of the Bureau of Mines in Fairbanks and at the smelter in Tacoma, Wash.

At the tungsten mines some work was done in 1918 on the Spruce Hen group and on the Scheelite claim, and it was reported that some tailings would be remilled at the Scheelite locality in 1918. Shipments of tungsten ore in 1918 have been reported from only one property in the Fairbanks district.

Antimony ore was produced in 1918 from only one mine in the Fairbanks district, and no special interest is being shown in the local antimony deposits.

### HOT SPRINGS DISTRICT.

The placer mines of the Hot Springs district are estimated to have produced gold worth $150,000 in 1918, compared with $450,000 in 1917. The production of placer tin in 1918 is estimated at 44 tons of concentrates, containing about 52,400 pounds of metallic tin, worth $45,500, practically all of which was recovered by sluicing old tailings and dumps. There was a general suspension of gold and tin mining because of shortage of labor and high cost of mining. Construction of a large ditch has been started by Howell & Cleveland, preparatory to hydraulic mining on the benches of Sullivan Creek. The gravels on lower Patterson Creek are said to have been extensively prospected by drilling, with encouraging results. The gold

and silver output of the placer mines of the Hot Springs district since the beginning of mining are given below. The placers of the Hot Springs district have also produced, since 1911, 232 tons of tin ore, estimated to contain about 276,260 pounds of tin, valued at $131,900.

*Placer gold and silver produced in the Hot Springs district, 1902–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1902–1903 | 12,717.79 | $262,900 | 1,818 | $964 |
| 1904 | 7,038.56 | 145,500 | 1,007 | 584 |
| 1905 | 5,805.00 | 120,000 | 831 | 507 |
| 1906 | 8,707.50 | 180,000 | 1,245 | 843 |
| 1907 | 8,465.63 | 175,000 | 1,210 | 798 |
| 1908 | 7,256.25 | 150,000 | 1,038 | 550 |
| 1909 | 15,721.88 | 325,000 | 2,248 | 1,169 |
| 1910 | 15,721.88 | 325,000 | 2,248 | 1,169 |
| 1911 | 37,974.37 | 785,000 | 5,430 | 2,932 |
| 1912 | 19,350.00 | 400,000 | 3,267 | 2,009 |
| 1913 | 19,350.00 | 400,000 | 3,267 | 1,973 |
| 1914 | 36,281.25 | 750,000 | 6,125 | 3,387 |
| 1915 | 29,508.75 | 610,000 | 4,982 | 2,526 |
| 1916 | 38,700.00 | 800,000 | 6,534 | 4,299 |
| 1917 | 21,768.75 | 450,000 | 3,675 | 3,028 |
| 1918 | 7,256.25 | 150,000 | 1,225 | 1,225 |
| | 291,623.86 | 6,028.400 | 46,150 | 27,963 |

## TOLOVANA DISTRICT.

The gold production of the placers of the Tolovana district in 1918 is estimated to be about $875,000, compared with $1,150,000 in 1917. This falling off in production is due largely to the working out of a number of claims but also to the exceptional dryness of the summer and to the scarcity of labor. Unless a strike is made in the district a further decrease may be expected in 1919.

A little placer work was done on Gunnison Creek and on Quail Creek, in the western part of the district. Some claims were staked on the benches along the west fork of Tolovana River, and it is expected that prospecting will be carried on there this winter. Several gold-lode prospects have been staked near Livengood, but nothing more than a little development work has been done on them.

Practically the total output of the district comes from Tolovana and vicinity, and the principal producing creeks are Tolovana, Amy, Lillian, Olive, Lucky, Ruth, and Gertrude. About 35 mines were operated in 1918, against 50 in 1917, and about 270 men were engaged in mining. Three or four of the plants employed more than 25 men each. About 8 of the mines were worked out during the season, or the deposits were found to be of too low grade to be worked next year. Three mines cleaned up the previous winter's dumps and then ceased to do further work. About 29 mines were expected to be in operation in 1919. Twenty-two mines had under-

ground workings. Pay ground at Livengood averages only about 75 cents to $1 a bedrock foot, the gravels averaging about 1½ feet in thickness, but the mines enjoy the advantage of hard, frozen ground that requires almost no timbering. The total gold and silver output of the Tolovana district is shown below, and a further statement on mining in the Tolovana district is given by Mr. Overbeck in another chapter of this report.

*Placer gold and silver produced in the Tolovana district, 1915–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1915 | 3,870.00 | $80,000 | 321 | $163 |
| 1916 | 33,862.50 | 700,000 | 2,813 | 1,851 |
| 1917 | 55,631.25 | 1,150,000 | 8,430 | 6,946 |
| 1918 | 42,328.12 | 875,000 | 4,060 | 4,060 |
| | 135,691.87 | 2,805,000 | 15,624 | 13,020 |

## RAMPART DISTRICT.

The production of placer gold in the Rampart district in 1918 was about $24,000, derived from the operation of 9 mines, employing 24 men, in the summer of 1918, and 2 mines, employing 4 men, in the winter of 1917–18. The most extensive operations were on Hunter Creek, where two hydraulicking plants have been installed. With the rest of Alaska, the Rampart district suffered from the scarcity of labor. Cassiterite is found in the concentrates of some of the mines, but none of it is being saved. The following table shows the total production of the district:

*Placer gold and silver produced in the Rampart district, 1896–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1896–1903 | 29,799.00 | $616,000 | 4,440 | $2,664 |
| 1904 | 4,353.75 | 90,000 | 649 | 376 |
| 1905 | 3,870.00 | 80,000 | 576 | 351 |
| 1906 | 5,805.00 | 120,000 | 865 | 588 |
| 1907 | 6,046.87 | 125,000 | 901 | 595 |
| 1908 | 3,628.12 | 75,000 | 540 | 286 |
| 1909 | 4,837.50 | 100,000 | 721 | 375 |
| 1910 | 2,080.12 | 43,000 | 310 | 167 |
| 1911 | 1,548.00 | 32,000 | 231 | 125 |
| 1912 | 1,548.00 | 32,000 | 274 | 169 |
| 1913 | 1,548.00 | 32,000 | 274 | 165 |
| 1914 | 1,451.25 | 30,000 | 257 | 142 |
| 1915 | 1,693.13 | 35,000 | 300 | 152 |
| 1916 | 1,935.00 | 40,000 | 343 | 226 |
| 1917 | 1,596.37 | 33,000 | 280 | 231 |
| 1918 | 1,161.00 | 24,000 | 206 | 206 |
| | 72,901.11 | 1,507,000 | 11,167 | 6,818 |

### SALCHAKET-TENDERFOOT DISTRICT.

The Tenderfoot district, which in past years, as the following table shows, yielded a considerable amount of gold, has practically ceased to produce. The output for 1918 probably did not exceed $6,000.

There were reported discoveries of gold in 1918, as in previous years, at several localities in the Salchaket and Goodpaster districts, but none of them have yet proved of importance.

*Placer gold and silver produced in Salchaket-Tenderfoot district, 1905–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1905 | (a) | (a) | (a) | (a) |
| 1906 | 4,837.50 | $100,000 | 989 | $673 |
| 1907 | 18,140.62 | 375,000 | 3,707 | 2,447 |
| 1908 | 18,140.62 | 375,000 | 3,707 | 1,965 |
| 1909 | 7,256.25 | 150,000 | 1,483 | 771 |
| 1910 | 4,837.50 | 100,000 | 989 | 534 |
| 1911 | 4,837.50 | 100,000 | 989 | 524 |
| 1912 | 4,837.50 | 100,000 | 989 | 608 |
| 1913 | 4,837.50 | 100,000 | 989 | 597 |
| 1914 | 4,837.50 | 100,000 | 989 | 547 |
| 1915 | 4,595.62 | 95,000 | 939 | 476 |
| 1916 | 3,870.00 | 80,000 | 790 | 520 |
| 1917 | 1,289.37 | 25,000 | 245 | 202 |
| 1918 | 290.25 | 6,000 | 59 | 59 |
| | 82,607.73 | 1,706,000 | 16,864 | 9,923 |

a Prospects only.

### CHISANA DISTRICT.

Very little authentic information concerning mining in the Chisana district in 1918 has been received. It is believed that mining was curtailed, as in most other Alaskan districts, and that the gold output was probably not worth more than $15,000. The total production of the district to date is shown below.

*Placer gold and silver produced in the Chisana district, 1913–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1913 | 1,935.00 | $40,000 | 465 | $280 |
| 1914 | 12,093.75 | 250,000 | 2,910 | 1,609 |
| 1915 | 7,740.00 | 160,000 | 1,862 | 944 |
| 1916 | 1,935.00 | 40,000 | 465 | 306 |
| 1917 | 1,935.00 | 40,000 | 420 | 346 |
| 1918 | 725.63 | 15,000 | 160 | 160 |
| | 26,364.38 | 545,000 | 6,282 | 3,645 |

## KANTISHNA DISTRICT.

The mineral production of the Kantishna district in 1918 consisted of placer gold worth about $30,000. About 25 or 30 men were engaged in mining. Preparations were made for mining silver-lead ore and antimony ore.

*Placer gold and silver produced in the Kantishna district, 1903–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1903–1906 | 8,465.62 | $175,000 | 1,325 | $795 |
| 1907 | 725.62 | 15,000 | 114 | 75 |
| 1908 | 725.62 | 15,000 | 114 | 60 |
| 1909 | 241.87 | 5,000 | 38 | 20 |
| 1910 | 483.75 | 10,000 | 76 | 41 |
| 1911 | 1,451.25 | 30,000 | 227 | 120 |
| 1912 | 1,451.25 | 30,000 | 227 | 140 |
| 1913 | 1,451.25 | 30,000 | 227 | 137 |
| 1914 | 967.50 | 20,000 | 152 | 84 |
| 1915 | 967.50 | 20,000 | 152 | 77 |
| 1916 | 1,451.25 | 30,000 | 227 | 149 |
| 1917 | 725.63 | 15,000 | 120 | 99 |
| 1918 | 1,451.25 | 30,000 | 227 | 227 |
| | 20,559.36 | 425,000 | 3,226 | 2,024 |

## BONNIFIELD DISTRICT.

The placer mines of the Bonnifield district produced gold worth about $8,000 in 1918. About five mines, employing 12 men, were operated on Moose, Daniels, and Healy creeks. Some work was done at the lode prospects on the divide between Moose and Eva creeks. No information has been received concerning the placers in the eastern part of the Bonnifield region, and it is believed that little mining was done there. One man was engaged in placer mining in a small way on Rainy Creek, tributary to Delta River. Some work was done on the molybdenite lodes on the Dry Delta. The placer production of the Bonnifield district since the beginning of mining is shown below.

*Placer gold and silver produced in the Bonnifield district, 1903–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1903–1906 | 1,451.25 | $30,000 | 227 | $136 |
| 1907 | 241.87 | 5,000 | 38 | 25 |
| 1908 | 241.87 | 5,000 | 38 | 20 |
| 1909 | 2,418.75 | 50,000 | 379 | 197 |
| 1910 | 483.75 | 10,000 | 76 | 41 |
| 1911 | 967.50 | 20,000 | 152 | 81 |
| 1912 | 967.50 | 20,000 | 152 | 93 |
| 1913 | 967.50 | 20,000 | 152 | 92 |
| 1914 | 1,451.25 | 30,000 | 227 | 126 |
| 1915 | 967.50 | 20,000 | 152 | 77 |
| 1916 | 483.75 | 10,000 | 76 | 50 |
| 1917 | 580.50 | 12,000 | 98 | 81 |
| 1918 | 580.50 | 12,000 | 91 | 91 |
| | 11,803.49 | 244,000 | 1,858 | 1,110 |

### NENANA COAL FIELD.

Mining of coal for shipment began in the Nenana field in 1918, when two small mines were opened under mining permits to supply coal for the railroad and other local use. This was the first production of coal from this field except a little that has been taken from time to time to supply fuel for some of the placer mines on Totatlanika Creek. No coal leases have yet been granted in the Nenana field.

### CIRCLE DISTRICT.

Mining in the Circle district in 1918 was confined as usual to the gold placers, which produced gold worth $175,000. About 35 mines, employing 93 men, were operated in the summer of 1918 and 15 mines, employing 28 men, in the winter of 1917-18. The dredge on Mastodon Creek was operated as usual. The supply of water was reported to be ample throughout the district. No new discoveries were made, and no important new projects were undertaken. The output of the placers of the Circle district, since mining began in 1894, is shown below.

*Placer gold and silver produced in the Circle district, 1894–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1894 | 483.75 | $10,000 | 123 | $77 |
| 1895 | 7,256.25 | 150,000 | 1,886 | 1,226 |
| 1896 | 33,862.50 | 700,000 | 8,794 | 6,080 |
| 1897 | 24,187.50 | 500,000 | 6,289 | 3,773 |
| 1898 | 19,350.00 | 400,000 | 5,031 | 2,968 |
| 1899 | 12,093.75 | 250,000 | 3,144 | 1,886 |
| 1900 | 12,093.75 | 250,000 | 3,144 | 1,886 |
| 1901 | 9,675.00 | 200,000 | 2,512 | 1,507 |
| 1902 | 9,675.00 | 200,000 | 2,512 | 1,331 |
| 1903 | 9,675.00 | 200,000 | 3,144 | 1,698 |
| 1904 | 9,675.00 | 200,000 | 3,144 | 1,823 |
| 1905 | 9,675.00 | 200,000 | 3,144 | 1,918 |
| 1906 | 14,512.50 | 300,000 | 3,773 | 2,565 |
| 1907 | 9,675.00 | 200,000 | 3,144 | 2,075 |
| 1908 | 8,465.63 | 175,000 | 2,212 | 1,166 |
| 1909 | 10,884.37 | 225,000 | 2,830 | 1,472 |
| 1910 | 10,884.37 | 225,000 | 2,830 | 1,528 |
| 1911 | 16,931.25 | 350,000 | 4,402 | 2,333 |
| 1912 | 15,721.87 | 325,000 | 2,439 | 1,500 |
| 1913 | 8,465.63 | 175,000 | 1,314 | 794 |
| 1914 | 10,884.37 | 225,000 | 1,689 | 934 |
| 1915 | 11,126.25 | 230,000 | 1,727 | 875 |
| 1916 | 14,512.50 | 300,000 | 2,252 | 1,482 |
| 1917 | 9,675.00 | 200,000 | 1,561 | 1,285 |
| 1918 | 8,465.63 | 175,000 | 1,798 | 1,798 |
| | 307,906.87 | 6,365,000 | 74,838 | 45,980 |

### FORTYMILE DISTRICT.

The gold output of the Fortymile district in 1918 was valued at $75,000 and was derived from the operation of about 60 mines, employing 93 men, in the summer of 1918, and 29 mines, employing 48

men, in the winter of 1917–18. There was no dredging in 1918, it being reported that the dredge that was previously operated was not suitable for the ground. The high benches near the mouth of Dennison Fork were prospected extensively, and it is said that plans are under consideration for the construction in 1919 of a ditch 21 miles long on the bank of Dennison Fork.

*Placer gold and silver produced in the Fortymile district, 1886–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1886–1903 | 193,500.00 | $4,000,000 | 30,553 | $22,915 |
| 1904 | 14,851.12 | 307,000 | 2,345 | 1,360 |
| 1905 | 12,384.00 | 256,000 | 1,955 | 1,193 |
| 1906 | 9,868.50 | 204,000 | 1,558 | 1,059 |
| 1907 | 6,772.50 | 140,000 | 1,069 | 706 |
| 1908 | 6,772.50 | 140,000 | 1,069 | 567 |
| 1909 | 10,884.37 | 225,000 | 1,719 | 894 |
| 1910 | 9,675.00 | 200,000 | 1,528 | 825 |
| 1911 | 9,575.00 | 200,000 | 1,528 | 810 |
| 1912 | 10,303.87 | 213,000 | 1,627 | 1,000 |
| 1913 | 4,837.50 | 100,000 | 764 | 461 |
| 1914 | 2,418.75 | 50,000 | 382 | 211 |
| 1915 | 2,418.75 | 50,000 | 382 | 194 |
| 1916 | 2,418.75 | 50,000 | 382 | 251 |
| 1917 | 3,870.00 | 80,000 | 624 | 513 |
| 1918 | 3,628.12 | 75,000 | 573 | 573 |
| | 304,278.73 | 6,290,000 | 48,058 | 33,532 |

## EAGLE DISTRICT.

The production of placer gold in the Eagle district in 1918 was about $25,000, or nearly double that of 1917. The increase was due to the operation of two new hydraulic plants. About 14 mines, employing 40 men, were operated in the summer of 1918, and 1 mine, employing 2 men, in the winter of 1917–18.

*Placer gold and silver produced in the Eagle and Seventymile districts, 1908–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1908 | 483.75 | $10,000 | 76 | $40 |
| 1909 | 1,209.37 | 25,000 | 191 | 99 |
| 1910 | 483.75 | 10,000 | 76 | 41 |
| 1911 | 580.50 | 12,000 | 92 | 49 |
| 1912 | 967.50 | 20,000 | 164 | 100 |
| 1913 | 2,418.75 | 50,000 | 382 | 231 |
| 1914 | 2,418.75 | 50,000 | 382 | 211 |
| 1915 | 1,935.00 | 40,000 | 305 | 155 |
| 1916 | 822.37 | 17,000 | 130 | 86 |
| 1917 | 628.88 | 13,000 | 96 | 75 |
| 1918 | 1,209.37 | 25,000 | 191 | 191 |
| | 13,157.99 | 272,000 | 2,085 | 1,278 |

### CHANDALAR DISTRICT.

Little information has been received concerning mining in the Chandalar district. The placers were apparently worked on about the customary scale, 4 summer mines and 3 winter mines, employing 10 and 6 men, respectively, producing gold worth about $13,000.

*Placer gold and silver produced in the Chandalar district, 1906–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1906–1912 | 2,902.50 | $60,000 | 416 | $241 |
| 1913 | 266.06 | 5,500 | 38 | 23 |
| 1914 | 241.87 | 5,000 | 35 | 19 |
| 1915 | 241.87 | 5,000 | 35 | 18 |
| 1916 | 435.37 | 9,000 | 62 | 41 |
| 1917 | 725.63 | 15,000 | 104 | 86 |
| 1918 | 628.88 | 13,000 | 96 | 96 |
| | 5,442.18 | 112,500 | 786 | 524 |

### KOYUKUK DISTRICT.

The gold placers of the Koyukuk district are believed to have produced gold worth about $150,000 in 1918. About 20 mines, employing 150 men, are reported as having operated in the summer of 1918, and 3 mines, employing 10 men, in the winter of 1917–18.

*Placer gold and silver produced in the Koyukuk district, 1900–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1900–1909 | 106,454.02 | $2,200,600 | 15,242 | $8,993 |
| 1910 | 7,740.00 | 160,000 | 1,108 | 598 |
| 1911 | 6,772.50 | 140,000 | 970 | 514 |
| 1912 | 9,675.00 | 200,000 | 1,385 | 852 |
| 1913 | 19,350.00 | 400,000 | 2,770 | 1,673 |
| 1914 | 12,577.50 | 260,000 | 1,800 | 995 |
| 1915 | 13,303.12 | 275,000 | 1,902 | 964 |
| 1916 | 14,996.25 | 310,000 | 2,147 | 1,413 |
| 1917 | 12,093.75 | 250,000 | 1,700 | 1,401 |
| 1918 | 7,256.25 | 150,000 | 860 | 860 |
| | 210,218.39 | 4,345,600 | 29,884 | 18,263 |

### INDIAN RIVER AND GOLD HILL DISTRICTS.

The production of gold from the Indian River and Gold Hill placers in 1918 was probably not more than $4,000. Only 2 mines, employing 8 men, were known to have operated in the Indian River district, and 1 mine in the Gold Hill district. A small amount of placer tin was saved at a placer gold mine on Mason Creek, in the

Gold Hill district, and gravels said to contain 2½ pounds of stream tin to the cubic yard were discovered on Moran Creek, a tributary of the Melozi. About 6 men were prospecting and digging a ditch on Moran Creek.

*Placer gold and silver produced in the Indian River and Gold Hill [a] districts, 1911–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1911 | 483.75 | $10,000 | 69 | $37 |
| 1912 | 1,185.19 | 24,500 | 170 | 105 |
| 1913 | 1,548.00 | 32,000 | 221 | 133 |
| 1914 | 1,209.37 | 25,000 | 173 | 96 |
| 1915 | 725.63 | 15,000 | 104 | 53 |
| 1916 | 483.75 | 10,000 | 69 | 45 |
| 1917 | 241.88 | 5,000 | 27 | 22 |
| 1918 | 193.50 | 4,000 | 29 | 29 |
| | 6,071.07 | 125,500 | 862 | 520 |

[a] Gold Hill placers included in 1918 only.

## IDITAROD DISTRICT.

The placer mines of the Iditarod district are believed to have yielded, in 1918, gold worth about $1,240,000, compared with $1,500,000 in 1917. Three dredges were operated, yielding about $750,000 in gold. It is reported that a claim on a hill at the head of Flat Creek yielded $84,000. About half the people of the Iditarod district are said to have left for the States.

*Placer gold and silver produced in the Iditarod district, 1910–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1910 | 24,187.50 | $500,000 | 4,254 | $2,297 |
| 1911 | 120,937.50 | 2,500,000 | 21,270 | 11,273 |
| 1912 | 169,312.50 | 3,500,000 | 29,778 | 18,313 |
| 1913 | 89,977.50 | 1,860,000 | 9,551 | 5,769 |
| 1914 | 99,652.50 | 2,060,000 | 10,578 | 5,849 |
| 1915 | 99,168.75 | 2,050,000 | 10,526 | 5,337 |
| 1916 | 94,331.25 | 1,950,000 | 10,013 | 6,589 |
| 1917 | 72,562.50 | 1,500,000 | 11,050 | 9,105 |
| 1918 | 59,985.00 | 1,240,000 | 9,000 | 9,000 |
| | 830,115.00 | 17,160,000 | 116,020 | 73,532 |

## RUBY DISTRICT.

The production of gold in the Ruby district in 1918 is reported to be about $400,000, which is only about half that of 1917. The decrease is due largely to the fact that the Greenstone dredge did not

operate, its ground having been worked out in 1917. Some of the smaller operators suspended work on account of high prices of supplies and material. A small amount of cassiterite was saved in mining for placer gold.

*Placer gold and silver produced in the Ruby district, 1907–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1907–8 | 48.38 | $1,000 | 7 | $4 |
| 1909 | | | | |
| 1910 | | | | |
| 1911 | | | | |
| 1912 | 8,465.63 | 175,000 | 1,157 | 712 |
| 1913 | 37,974.37 | 785,000 | 5,188 | 3,134 |
| 1914 | 48,375.00 | 1,000,000 | 6,609 | 3,655 |
| 1915 | 33,862.50 | 700,000 | 4,626 | 2,345 |
| 1916 | 41,118.75 | 850,000 | 5,618 | 3,697 |
| 1917 | 42,811.88 | 885,000 | 6,073 | 5,046 |
| 1918 | 19,350.00 | 400,000 | 3,000 | 3,000 |
| | 232,006.51 | 4,796,000 | 32,278 | 21,593 |

## INNOKO AND TOLSTOI DISTRICTS.

The production of placer gold in the Innoko and Tolstoi districts in 1918 was probably about $120,000. The output of the Tolstoi district decreased considerably, only one mine being reported as productive in 1918, but it is said that encouraging new discoveries have been made.

*Placer gold and silver produced in the Innoko and Tolstoi districts, 1907–1918.*[a]

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1907 | 628.87 | $13,000 | 67 | $44 |
| 1908 | 3,483.00 | 72,000 | 370 | 196 |
| 1909 | 16,447.50 | 340,000 | 1,746 | 908 |
| 1910 | 15,721.87 | 325,000 | 1,669 | 901 |
| 1911 | 12,093.75 | 250,000 | 1,284 | 681 |
| 1912 | 12,093.75 | 250,000 | 1,284 | 681 |
| 1913 | 13,545.00 | 280,000 | 1,438 | 869 |
| 1914 | 9,675.00 | 200,000 | 1,027 | 568 |
| 1915 | 9,191.25 | 190,000 | 976 | 495 |
| 1916 | 10,642.50 | 220,000 | 1,130 | 744 |
| 1917 | 8,465.63 | 175,000 | 1,113 | 917 |
| 1918 | 5,805.00 | 120,000 | 608 | 608 |
| | 117,793.12 | 2,435,000 | 12,712 | 7,612 |

[a] Includes Tolstoi district in 1917 and 1918.

## MARSHALL DISTRICT.

The output of placer gold in the Marshall district in 1918 is estimated at about $150,000. Since mining began in 1914 the Marshall placers have yielded gold worth about $885,000.

*Placer gold and silver produced in the Marshall district, 1914–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (fine ounces). | Value. | Quantity (fine ounces). | Value. |
| 1914 | 725.62 | $15,000 | 94 | $52 |
| 1915 | 1,209.37 | 25,000 | 156 | 79 |
| 1916 | 13,061.25 | 270,000 | 1,686 | 1,109 |
| 1917 | 20,559.37 | 425,000 | 3,300 | 2,719 |
| 1918 | 7,256.25 | 150,000 | 940 | 940 |
| | 42,811.86 | 885,000 | 6,176 | 4,899 |

## STUYAHOK RIVER.

Some interest was aroused on the lower Yukon in the fall of 1918 by the report that valuable gold placers had been located on Stuyahok River, about 6 miles north of Tucker's fish camp. The Stuyahok is tributary from the south to Bonasila River, which enters the Yukon about 10 miles below Anvik. It has been known[1] that gold exists on the Stuyahok, but no mining has hitherto been done. No detailed information has been received concerning the discovery, but it has recently been reported that the excitement is subsiding.

## KUSKOKWIM REGION.

The production of gold in the Kuskokwim region in 1918, according to such scanty information as is available, was about $100,000. The greater part of the output came from the Mount McKinley precinct, where a dredge that was shipped to the locality several years ago began working on Candle Creek. The operation of the dredge has not thus far been satisfactory, as there has been repeated trouble with part of the machinery. In the Goodnews Bay or Quinhagak district about 6 mines were operated, employing about 30 men, and producing gold worth about $30,000. The discoveries reported from the Goodnews Bay district in 1917 have not yet proved to be of great importance. Placer mining still continues in a small way in the Georgetown and Tuluksak-Aniak districts.

## NORTON SOUND.

A little placer gold was produced in 1918, as in previous years, from Bonanza Creek, in the St. Michael district, where the operations of 2 small mines were reported. The placer mines of Bonanza Creek also yielded a few pounds of scheelite concentrates in 1918. This is the first recorded production of tungsten from this district. Lignite was mined in the summer of 1918 near Unalaklik for shipment to Nome and St. Michael.

[1] Harrington, G. L., The Anvik-Andreafski region, Alaska: U. S. Geol. Survey Bull. 683, p. 56, 1918.

## SEWARD PENINSULA.

The value of the mineral production of Seward Peninsula in 1918 was about $1,195,172, compared with $2,747,000 in 1917. Of the output in 1918, $1,108,000 represents the value of the placer gold and $87,172 the value of the miscellaneous products, including tin, tungsten, silver, and platinum.

The production of placer gold was less than half that of 1917 and was the smallest since 1898. The decrease was due to labor difficulties, to the high cost of operating, and to unfavorable climatic conditions, including deep frost, scanty water, and a short season.

*Placer gold produced in Seward Peninsula, 1918, by districts.*

| | |
|---|---|
| Nome | $447,000 |
| Solomon | 49,000 |
| Council | 307,000 |
| Fairhaven | 113,000 |
| Koyuk | 135,000 |
| Kougarok | 50,000 |
| Port Clarence | 7,000 |

Twenty-one gold dredges operated during the season of 1918, seven less than in 1917. The dredges employed 152 men and produced gold worth about $466,000, or 42.1 per cent of the total production of Seward Peninsula. Of the dredges six were in the Nome district, seven in the Council district, five in the Solomon district, two in the Fairhaven district, and one in the Kougarok district.

Twenty-eight underground mines, employing about 177 men, operated in 1918, producing gold worth about $279,000, or 25.2 per cent of the total production of the peninsula. Of the underground mines 21 were in the Nome district, 4 in the Fairhaven district, and 3 in the Koyuk district.

Twenty-four hydraulic mines employed about 170 men and produced gold worth $259,500, or 23.4 per cent of the total production. Of the hydraulic mines 10 were in the Nome district, 1 in the Solomon district, 4 in the Council district, 5 in the Fairhaven district, 3 in the Koyuk district, and 1 in the Kougarok district.

Fifty-five open-cut mines, other than hydraulic, employed 134 men and produced gold worth $103,500, or 9.3 per cent of the total production. Of the open-cut mines 13 were in the Nome district, 6 in the Council district, 11 in the Fairhaven district, 15 in the Kougarok district, 4 in the Koyuk district, and 6 in the Port Clarence district.

The only new strike of the season was made on Poorman bench, Monument Creek, in the Nome district, where gravels carrying about $32 to the cubic yard were discovered.

The total production of tin was much less than in 1917. Only one tin dredge on Buck Creek, in the York district, operated in 1918. A

small amount of tin concentrates was also produced by sluicing. Placer tin has been discovered on Potato Creek, which flows northwestward from Potato Mountain, and also on Humboldt Creek, tributary to Goodhope River, in the Fairhaven district.

The production of tungsten was less than in 1917. It was wholly incidental to the mining of placer gold, no operations being conducted in 1918 for the recovery of scheelite alone.

About 56 ounces of platinum was recovered from the gold placers of Seward Peninsula. Most of this came from Dime Creek, in the Koyuk district, but a small amount was obtained from Bear Creek, in the Fairhaven district.

Little work was done on the lodes of Seward Peninsula in 1918, and no ore was shipped. Considerable work preparatory to mining was done on the Lost River tin lodes and on a silver-lead lode on Kougarok River, where some ore was mined. A further statement on mining in Seward Peninsula is given in another chapter of this report.

## KOBUK RIVER.

The gold production of Kobuk River for 1918 is estimated at $15,000. About 35 men were engaged in mining operations. It is reported that favorable prospects were discovered on California Creek, a tributary of the Kugaluktuk. About 150 tons of coal is said to have been mined on the Kobuk about 25 miles above Squirrel River.

# WATER-POWER INVESTIGATIONS IN SOUTHEASTERN ALASKA.[1]

By George H. Canfield.

## INTRODUCTION.

Systematic investigation of the water resources of Alaska was begun by the United States Geological Survey in 1906 and has been carried on in different parts of the Territory to the present time. This investigation was undertaken in response to the need for definite information in regard to water available for many uses, among which the most important are hydraulicking, dredging, and supplying power for mines, canneries, and sawmills.

The investigation of the water resources of southeastern Alaska was begun by the Geological Survey in cooperation with the Forest Service in 1915 and was designed to determine both the location and the possibilities of water-power sites. The results of previous years' work have already been published.[2]

The Geological Survey maintained a number of gaging stations in southeastern Alaska throughout the year, and other stations were installed in cooperation with individuals and corporations. The records obtained at these stations are contained in this paper. Acknowledgment is made to those who have assisted in this work, particularly to Mr. W. G. Weigle, special agent of the Forest Service at Ketchikan, and to Mr. Philip H. Dater, district engineer at Portland, Oreg.

The stations for which the records are presented are the following:

Myrtle Creek at Niblack.
Ketchikan Creek at Ketchikan.
Fish Creek near Sea Level.
Swan Lake outlet at Carroll Inlet.
Orchard Lake outlet at Shrimp Bay.
Shelockum Lake outlet at Bailey Bay.
Karta River at Karta Bay.
Cascade Creek at Thomas Bay.
Green Lake outlet at Silver Bay.
Baranof Lake outlet at Baranof.
Sweetheart Falls Creek near Snettisham.
Crater Lake outlet at Speel River, Port Snettisham.
Long River below Second Lake, at Port Snettisham.
Speel River at Port Snettisham.
Grindstone Creek at Taku Inlet.

[1] In cooperation with the United States Forest Service.
[2] U. S. Geol. Survey Bull. 662, pp. 100–154, 1918; Bull. 692, pp. 43–83, 1919.

Carlson Creek at Sunny Cove.
Sheep Creek near Thane.
Gold Creek at Juneau.

## STATION RECORDS.

### MYRTLE CREEK AT NIBLACK, PRINCE OF WALES ISLAND.

LOCATION.—Halfway between beach and Myrtle Lake outlet, which is one-third mile from tidewater, 1 mile from Niblack, in north arm of Moira Sound, Prince of Wales Island, and 35 miles by water from Ketchikan.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—July 30, 1917, to December 31, 1918.

GAGE.—Stevens continuous water-stage recorder on right bank; reached by a trail which leaves beach near the mouth of the creek.

DISCHARGE MEASUREMENTS.—At medium and high stages made from a cable across creek at outlet of lake; at low stages made by wading.

CHANNEL AND CONTROL.—The gage is in a pool 10 feet upstream from a contracted portion of the channel, at a rocky riffle that forms a well-defined and permanent control. At the cable section the bed is smooth, the water deep, and the current uniform and sluggish.

EXTREMES OF DISCHARGE.—Maximum stage recorded during the period from water-stage recorder, 4.40 feet at 5 p. m. November 18, 1917; discharge estimated from an extension of the rating curve, 387 second-feet; minimum discharge unknown, estimated at 30 second-feet in September, 1918.

ICE.—Stage-discharge relation not affected by ice.

ACCURACY.—Stage-discharge relation permanent. Rating curve, determined by four discharge measurements, is very well defined between 36 and 220 second-feet. Operation of water-stage recorder satisfactory for the following periods only: July 30 to November 28, December 16–22, 1917; February 14–15, March 20–25, April 7–10, October 24 to November 6, December 1, and December 30–31, 1918; unsatisfactory for other days of period because of stopping of clock due to condensation of moisture on and final rusting through of hair spring of the escapement. Discharge ascertained for periods recorder was operating by applying to rating table mean daily gage heights; for periods recorder was not operating, by determining with a planimeter the monthly means from an estimated hydrograph drawn by means of staff gage readings by observer about once every 10 days, maximum and minimum stages indicated by the recorder, and recorded hydrograph, and by comparison of the record for this station with that for Karta River. Results good except for periods when the recorder was stopped, for which they are fair.

Myrtle Lake, the outlet of which is 800 feet from Niblack Anchorage, is 95 feet above sea level and covers 122 acres. Niblack Lake, the outlet of which is 5,700 feet from Niblack Anchorage, is 450 feet above sea level, and covers 383 acres. Mary Lake, unsurveyed, is about 600 feet above sea level and is a mile long and one-fourth to one-half mile wide. The large lake area in this small drainage basin is the cause of the well-maintained flow during the winter and periods of little rainfall.

*Discharge measurements of Myrtle Creek at Niblack, during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. |
|---|---|---|
| | *Feet.* | *Sec.-ft.* |
| Oct. 16 | 1.78 | 62 |
| Oct. 24 | 2.24 | 101 |

*Daily discharge, in second-feet, of Myrtle Creek at Niblack, for 1917–18.*

| Day. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Day. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1917. | | | | | | | | | | | | | |
| 1 | | 45 | 69 | 85 | 295 | | 16 | | 65 | 79 | 76 | 260 | 64 |
| 2 | | 46 | 63 | 118 | 267 | | 17 | | 68 | 70 | 88 | 332 | 62 |
| 3 | | 42 | 58 | 128 | 220 | | 18 | | 91 | 71 | 134 | 371 | 59 |
| 4 | | 41 | 55 | 126 | 220 | | 19 | | 140 | 82 | 120 | 340 | 57 |
| 5 | | 40 | 52 | 151 | 254 | | 20 | | 117 | 75 | 134 | 281 | 56 |
| 6 | | 40 | 50 | 120 | 332 | | 21 | | 93 | 75 | 120 | 233 | 55 |
| 7 | | 39 | 48 | 105 | 340 | | 22 | | 108 | 77 | 134 | 194 | 54 |
| 8 | | 38 | 46 | 99 | 288 | | 23 | | 95 | 73 | 129 | 175 | |
| 9 | | 38 | 44 | 93 | 240 | | 24 | | 84 | 70 | 121 | 175 | |
| 10 | | 38 | 43 | 92 | 254 | | 25 | | 74 | 73 | 114 | 169 | |
| 11 | | 44 | 43 | 97 | 220 | | 26 | | 79 | 76 | 102 | 175 | |
| 12 | | 42 | 59 | 91 | 206 | | 27 | | 104 | 88 | 93 | 200 | |
| 13 | | 41 | 65 | 92 | 288 | | 28 | | 121 | 120 | 146 | 169 | |
| 14 | | 42 | 69 | 86 | 371 | | 29 | | 97 | 112 | 151 | 154 | |
| 15 | | 56 | 80 | 81 | 318 | | 30 | 42 | 84 | 100 | 169 | 140 | |
| | | | | | | | 31 | 41 | 76 | | 200 | | |

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1918. | | | | | | | | | | | | |
| 1 | | | | | | 79 | | | | | 146 | 233 |
| 2 | | | | | | | | | | | 134 | |
| 3 | | | | | | | | 45 | | | 126 | |
| 4 | 197 | | | | | | | | | | 111 | |
| 5 | | | | | | | | 38 | | | 109 | |
| 6 | | | | | | | 52 | | | | 157 | |
| 7 | | | | 40 | | | | | | | | |
| 8 | | | | 67 | | | | | | | | |
| 9 | | | | 104 | 114 | | | | | | | |
| 10 | | | | 97 | | | | | | | | |
| 11 | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | |
| 14 | | 73 | | | | | | | | | | |
| 15 | | 68 | | | | | 44 | | 33 | | | |
| 16 | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | |
| 18 | 149 | | | | | 81 | | | | | | |
| 19 | | | | | | | | | | | | |
| 20 | | | 40 | | | | | | | | | |
| 21 | | | 50 | | | | | | | | | |
| 22 | | | 48 | 88 | | | | | | | | |
| 23 | | | 45 | | | | | | | | | |
| 24 | | | 46 | | | | | | | 102 | | |
| 25 | | | 48 | | 71 | | | | | 104 | | |
| 26 | | | | 71 | | 71 | | | | 140 | | |
| 27 | | | | | 73 | | 39 | | | 146 | | |
| 28 | 97 | | | | | | | | | 129 | | |
| 29 | | | | | | | | | 45 | 124 | | |
| 30 | | | | | | | | | | 163 | | 92 |
| 31 | | | | | | | | 40 | | 157 | | 84 |

NOTE.—Discharge estimated for following periods, because of unsatisfactory operation of water-stage recorder: Nov. 29–30, Dec. 1–31, 1917 (mean discharge, 82 second-feet), Jan. 1–31 (mean discharge, 140 second-feet), Feb. 1–28 (mean discharge, 77 second-feet), Mar. 1–31 (mean discharge, 48 second-feet), April 1–30 (mean discharge, 70 second-feet), May 1–31 (mean discharge, 104 second-feet), June 1–30 (mean discharge, 83 second-feet), July 1–31 (mean discharge, 48 second-feet), August 1–31 (mean discharge, 50 second-feet), Sept. 1–30 (mean discharge, 43 second-feet), Oct. 1–15 (mean discharge, 90 second-feet), Oct. 16–23 (mean discharge, 105 second-feet), Nov. 7–31 (mean discharge, 130 second-feet), and Dec. 2–29, 1918 (mean discharge, 100 second-feet), by a comparison with hydrograph for Karta River, and from staff gage readings by observer, maximum and minimum stages indicated by recording pencil and gage-height graph (Dec. 16–22, 1917, Feb. 14–15, Mar. 20–25, and Apr. 7–10).

*Monthly discharge of Myrtle Creek at Niblack for 1917–18.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| 1917. | | | | |
| August | 140 | 38 | 68.6 | 4,220 |
| September | 120 | 43 | 69.5 | 4,140 |
| October | 200 | 76 | 116 | 7,100 |
| November | 340 | 140 | 249 | 14,830 |
| December | | 50 | 82 | 5,040 |
| The period | | | | 35,300 |
| 1918. | | | | |
| January | 220 | 80 | 140 | 8,610 |
| February | 134 | | 77 | 4,280 |
| March | 60 | 40 | 48 | 2,950 |
| April | 138 | 40 | 70 | 4,170 |
| May | 151 | 71 | 104 | 6,400 |
| June | 109 | 71 | 83 | 4,940 |
| July | 70 | 39 | 48 | 2,950 |
| August | 73 | 38 | 50 | 3,070 |
| September | 112 | 32 | 43 | 2,560 |
| October | 163 | | 105 | 6,460 |
| November | | | 130 | 7,740 |
| December | 233 | | 104 | 6,400 |
| The year | 233 | 32 | 835 | 60,500 |

NOTE.—Figures for December, 1917, to December, 1918, mostly estimated. See footnote to table of daily discharge.

### KETCHIKAN CREEK AT KETCHIKAN.

LOCATION.—One-fourth mile below power house of Citizens Light, Power & Water Co., one-third mile northeast of Ketchikan post office, 200 feet downstream from mouth of Schoenbar Creek (entering from right), 1¼ miles from mouth of Granite Basin Creek (entering from left), and 1½ miles from outlet of Ketchikan Lake.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—November 1, 1909, to June 30, 1912; June 9, 1915, to February 29, 1916.

GAGE.—Vertical staff fastened to a telephone pole near board walk on left bank at bend of creek 200 feet downstream from mouth of Schoenbar Creek; read once daily between 7 and 8 a. m. by employee of Citizens Light, Power & Water Co. The gage used since June 9, 1915, consists of the standard United States Geological Survey enameled gage, section graduated in hundredths, half-tenths, and tenths from zero to 10 feet. The original gage, established November, 1909, and read until June 30, 1912, is at same location and same datum. It is a staff with graduations painted every tenth foot.

DISCHARGE MEASUREMENTS.—At medium and high stages from footbridge about 500 feet upstream from gage (measuring section poor, as the bridge makes an angle of 20° with the current, and at high stages the flow is broken by large stumps near left bank and at middle of bridge); at low stages, by wading 50 feet below bridge or at another section 100 feet above gage. The flow of Schoenbar Creek has been added to obtain total flow past gage.

CHANNEL AND CONTROL.—Gage is located in a large, deep pool of still water at a bend in river. The bed of the stream at the outlet of this pool is a solid rock ledge, but changes in a gravel bar at lower right side of pool cause occasional changes in stage-discharge relation.

EXTREMES OF STAGE.—Maximum stage recorded during year 4.7 feet November 29; minimum stage recorded, 0.08 foot February 25–26 and March 6–12.

1909–1918: Maximum stage recorded, 8.3 feet November 18, 1917; minimum stage recorded, 0.08 foot February 25–26 and March 6–12.

WINTER FLOW.—Ice forms along banks but control remains open.

DIVERSIONS.—A small quantity of water is diverted above the station for the use of Ketchikan, New England Fish Co., and Standard Oil Co.

REGULATIONS.—Small timber dam and head gates are located at outlet of Ketchikan Lake. Water diverted through power house is returned to river above gage but causes very little diurnal fluctuation. During low water the flow is increased by water from the reservoir.

ACCURACY.—Stage-discharge relation changed during high water August 19, 1917, and large tree trunk lodged lengthwise on control, probably during high water October 11, 1918. Sufficient discharge measurements have not yet been made to define rating curves applicable August 19, 1917, to December 31, 1918.

COOPERATION.—The gage readings were taken by the Citizens Light, Power & Water Co.

*Discharge measurements of Ketchikan Creek at Ketchikan during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| Apr. 23 | 1.01 | 200 | Oct. 17 | a 1.77 | 363 |
| May 7 | 1.36 | 330 | 23 | a .87 | 170 |
| Aug. 12 | .45 | 103 | | | |

a Stage-discharge relation changed by large tree trunk lodged on control.

*Daily gage height, in feet, of Ketchikan Creek at Ketchikan for 1918.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.1 | 0.24 | 0.20 | 0.20 | 0.82 | 0.86 | 1.00 | 0.80 | 0.38 | 0.30 | 2.6 | 2.7 |
| 2 | 2.25 | .20 | .20 | .24 | 1.46 | .70 | .92 | .76 | .36 | .50 | 1.60 | 2.4 |
| 3 | 1.3 | 1.80 | .18 | .36 | 1.70 | .70 | .84 | .60 | .30 | .86 | .80 | 1.85 |
| 4 | 2.1 | 1.20 | .10 | .40 | 1.70 | .68 | .70 | .30 | .30 | 4.1 | .64 | .68 |
| 5 | 1.2 | .84 | .10 | .26 | 1.60 | .50 | .70 | .56 | .28 | 4.0 | 1.00 | .40 |
| 6 | 1.0 | .66 | .08 | .18 | 1.65 | .44 | .72 | .26 | .26 | 1.85 | 2.3 | .18 |
| 7 | .70 | .64 | .08 | .24 | 1.6 | .36 | .74 | 2.1 | .20 | 1.44 | 1.65 | .64 |
| 8 | .10 | .50 | .08 | .46 | 1.3 | .30 | .70 | 1.95 | .20 | 2.6 | 1.38 | .56 |
| 9 | .10 | .76 | .08 | 1.00 | 1.24 | .24 | .66 | 1.8 | .18 | 1.6 | .90 | .44 |
| 10 | .20 | .66 | .08 | .48 | 1.20 | .60 | .70 | 1.5 | .30 | 1.48 | .68 | .30 |
| 11 | .44 | .60 | .08 | .60 | 1.16 | .90 | .50 | 1.00 | .28 | 4.35 | .40 | .26 |
| 12 | .46 | .40 | .08 | .60 | 1.10 | .94 | .66 | .90 | .20 | 1.9 | .76 | .18 |
| 13 | .44 | .30 | .10 | .66 | 1.10 | 1.00 | .50 | .40 | .20 | 1.50 | 1.38 | .18 |
| 14 | .28 | .24 | .10 | .70 | .96 | 1.10 | .46 | .34 | .18 | 1.46 | 1.18 | 1.30 |
| 15 | .46 | .20 | .10 | .76 | .90 | 1.10 | .54 | .36 | .10 | 1.20 | .68 | 1.20 |
| 16 | .42 | .18 | .10 | .70 | 1.00 | 1.08 | .44 | .46 | .18 | 1.26 | .76 | 1.20 |
| 17 | 1.20 | .18 | .10 | .66 | 1.10 | 1.08 | .40 | .48 | 1.30 | 2.20 | .48 | 1.36 |
| 18 | 1.44 | .16 | .10 | 1.30 | 1.10 | .96 | .40 | .46 | 1.10 | 1.10 | .30 | 1.40 |
| 19 | .82 | .10 | .10 | 1.68 | 1.14 | .90 | .40 | .68 | .30 | 1.6 | .28 | 1.20 |
| 20 | .60 | .10 | .10 | 1.50 | 1.18 | .90 | .38 | 1.30 | .18 | 2.45 | .30 | .60 |
| 21 | .46 | .10 | .40 | 1.46 | 1.20 | .88 | .36 | 1.10 | .18 | 1.45 | 1.70 | .56 |
| 22 | 1.28 | .10 | .18 | 1.48 | .90 | .86 | .36 | 2.35 | .18 | .80 | 1.20 | .48 |
| 23 | 1.30 | .10 | .20 | 1.30 | .84 | .86 | .36 | 1.95 | .50 | .66 | 1.26 | .90 |
| 24 | 1.34 | .10 | .36 | .90 | .70 | .86 | .34 | 1.40 | .28 | .68 | 1.60 | .76 |
| 25 | .74 | .08 | .38 | .86 | .68 | .90 | .48 | 1.10 | 1.30 | .48 | 1.70 | 2.2 |
| 26 | .60 | .08 | .30 | .84 | .60 | .96 | .56 | 1.0 | .70 | 2.80 | 1.60 | 3.0 |
| 27 | .66 | .10 | .36 | .74 | .60 | .90 | 2.00 | 2.3 | .26 | 1.65 | 1.38 | 1.30 |
| 28 | .54 | .30 | .40 | .74 | 1.50 | .70 | 2.00 | 1.38 | .20 | 1.6 | 2.5 | .70 |
| 29 | .40 | ...... | .46 | .80 | 1.10 | .70 | 1.08 | 1.40 | .20 | 1.36 | 4.7 | .54 |
| 30 | .24 | ...... | .26 | .96 | 1.08 | .86 | .84 | .78 | .18 | 1.50 | 3.4 | .30 |
| 31 | .20 | ...... | .20 | ...... | .98 | ...... | 1.00 | .70 | ...... | 2.65 | ...... | .20 |

### FISH CREEK NEAR SEA LEVEL, REVILLAGIGEDO ISLAND.

LOCATION.—In latitude 55° 24′ W., near outlet of Lower Lake on Fish Creek, 600 feet from tidewater at head of Thorne Arm, 2 miles northwest of mine at Sea Level, and 25 miles by water from Ketchikan.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—May 19, 1915, to December 31, 1918.

GAGE.—Stevens water-stage recorder on right shore of Lower Lake, 200 feet above outlet.

DISCHARGE MEASUREMENTS.—At medium and high stages made from cable across creek, 1 mile upstream from gage and 500 feet above head of Lower Lake; at low stages made by wading at cable. Only one small creek enters Lower Lake, at point opposite gage, between the cable site and control.

CHANNEL AND CONTROL.—The lake is about 500 feet wide opposite the gage. Outlet consists of two channels, each about 60 feet wide, separated by an island 40 feet wide. From the lake to tidewater, 200 feet, the creek falls about 20 feet. Bedrock exposed at the outlet of the lake forms a well-defined and permanent control.

EXTREMES OF DISCHARGE.—Maximum stage recorded during year, 3.52 feet at 12 a. m. January 1 (discharge computed from an extension of rating curve, 3,220 second-feet); minimum stage, 0.67 foot, March 13 (discharge, 46 second-feet).

1915–1918: Maximum stage recorded, 5.33 feet November 1, 1917 (discharge, 4,600 second-feet); minimum stage, 0.50 foot, February 11, 1916 (discharge, 22 second-feet).

ICE.—Lower Lake freezes over, but as gage is set back in the bank ice does not form in well, and the relatively warm water from the lake and the swift current keep the control open.

ACCURACY.—Stage-discharge relation permanent. Rating curve well defined below and extended above 1,500 second-feet. Operation of water-stage recorder satisfactory except for period indicated by break in record shown in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table mean gage heights for regular intervals of day. Results good, except for short period of break in record, for which they are fair.

There are three large lakes in the upper drainage basin. Big Lake, 2 miles from beach at an elevation of 275 feet, covers 1,700 acres; Third Lake, 250 acres; and Mirror Lake, at an elevation of 1,000 feet, 800 acres. Two-thirds of the drainage basin is covered with a thick growth of timber and brush interspersed with occasional patches of beaver swamp and muskeg. Only the tops of the highest mountains are bare. This large area of lake surface and vegetation, notwithstanding the steep slopes and shallow soil, affords a little ground storage and after a heavy precipitation maintains a good run-off. During a dry, hot period in summer, however, after the snow has melted, the flow becomes very low because of lack of ice or glaciers in the drainage basin.

*Discharge measurements of Fish Creek near Sea Level during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. |
|---|---|---|
| | *Feet.* | *Sec.-ft.* |
| Aug. 9 | 2.00 | 728 |
| Oct. 18 | 1.53 | 374 |

*Daily discharge, in second-feet, of Fish Creek near Sea Level for 1918.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2,020 | 132 | 132 | 168 | 318 | 546 | 492 | 395 | 329 | 157 | 1,100 | 1,960 |
| 2 | 1,730 | 123 | 153 | 142 | 334 | 447 | 480 | 340 | 259 | 136 | 875 | 1,300 |
| 3 | 1,280 | 197 | 139 | 123 | 702 | 408 | 395 | 269 | 202 | 182 | 610 | 710 |
| 4 | 1,200 | 414 | 114 | 139 | 1,050 | 395 | 329 | 210 | 161 | 962 | 373 | 474 |
| 5 | 875 | 512 | 101 | 132 | 1,250 | 421 | 290 | 176 | 136 | 1,680 | 324 | 368 |
| 6 | 632 | 460 | 91 | 119 | 1,030 | 486 | 270 | 157 | 111 | 1,150 | 384 | 340 |
| 7 | 466 | 351 | 82 | 111 | 734 | 525 | 264 | 210 | 98 | 726 | 655 | 312 |
| 8 | 340 | 329 | 73 | 139 | 574 | 595 | 275 | 632 | 87 | 632 | 581 | 302 |
| 9 | 264 | 312 | 65 | 243 | 525 | 710 | 285 | 670 | 80 | 574 | 480 | 254 |
| 10 | 220 | 351 | 62 | 275 | 506 | 830 | 301 | 602 | 89 | 625 | 384 | 233 |
| 11 | 188 | 280 | 58 | 312 | 560 | 938 | 368 | 473 | 106 | 956 | 307 | 210 |
| 12 | 168 | 228 | 55 | 285 | 553 | 875 | 460 | 351 | 119 | 1,150 | 440 | 188 |
| 13 | 149 | 184 | 50 | 285 | 518 | 710 | 447 | 269 | 119 | 1,250 | 581 | 157 |
| 14 | 116 | 149 | 59 | 269 | 499 | 618 | 384 | 499 | 114 | 822 | 532 | 153 |
| 15 | 116 | 119 | 78 | 259 | 512 | 525 | 340 | 176 | 101 | 532 | 362 | 136 |
| 16 | 132 | 104 | 80 | 233 | 512 | 499 | 312 | 153 | 91 | 373 | 334 | 302 |
| 17 | 243 | 89 | 80 | 192 | 506 | 505 | 285 | 180 | 87 | 307 | 285 | 440 |
| 18 | 340 | 80 | 80 | 220 | 454 | 518 | 275 | 197 | 114 | 318 | 228 | 525 |
| 19 | 312 | 67 | 84 | 197 | 395 | 505 | 254 | 280 | 192 | 486 | 188 | 492 |
| 20 | 264 | 65 | 87 | 648 | 362 | 460 | 238 | 974 | 210 | 1,020 | 157 | 368 |
| 21 | 233 | 58 | 108 | 553 | 334 | 421 | 224 | 1,000 | 184 | 929 | 224 | 285 |
| 22 | 329 | 64 | 116 | 441 | 346 | 390 | 197 | 806 | 153 | 670 | 346 | 233 |
| 23 | 539 | 64 | 119 | 384 | 330 | 368 | 180 | 1,310 | 132 | 506 | 506 | 220 |
| 24 | 602 | 64 | 132 | 346 | 307 | 373 | 165 | 1,030 | 129 | 440 | 539 | 243 |
| 25 | 512 | 65 | 132 | 302 | 296 | 421 | 161 | 710 | 165 | 414 | 532 | 285 |
| 26 | 402 | 65 | 119 | 280 | 302 | 499 | 168 | 567 | 378 | 618 | 662 | 632 |
| 27 | 324 | 71 | 106 | 264 | 373 | 546 | 180 | 480 | 428 | 1,050 | 640 | 539 |
| 28 | 285 | 108 | 142 | 259 | 610 | 492 | 447 | 581 | 334 | 1,010 | 574 | 414 |
| 29 | 224 | ....... | 172 | 275 | 1,000 | 428 | 670 | 702 | 259 | 848 | 960 | 312 |
| 30 | 180 | ....... | 188 | 312 | 902 | 402 | 539 | 595 | 473 | 857 | 1,730 | 243 |
| 31 | 149 | ....... | 188 | ....... | 718 | ....... | 373 | 447 | ....... | 965 | ....... | 192 |

NOTE.—Discharge Dec. 2–6 estimated, because of clock stopping, from maximum and minimum stages indicated by the recorder and from a comparison of the hydrograph for this station with that for Karta River.

*Monthly discharge of Fish Creek near Sea Level for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 2,020 | 116 | 479 | 29,500 |
| February | 512 | 58 | 182 | 10,100 |
| March | 188 | 50 | 105 | 6,460 |
| April | 648 | 111 | 264 | 15,700 |
| May | 1,250 | 302 | 562 | 34,600 |
| June | 938 | 368 | 529 | 31,500 |
| July | 670 | 161 | 324 | 19,900 |
| August | 1,310 | 153 | 498 | 30,600 |
| September | 473 | 80 | 181 | 10,800 |
| October | 1,680 | 136 | 721 | 44,300 |
| November | 1,730 | 157 | 530 | 31,500 |
| December | 1,960 | 136 | 414 | 25,500 |
| The year | 2,020 | 50 | 401 | 290,000 |

### SWAN LAKE OUTLET AT CARROLL INLET, REVILLAGIGEDO ISLAND.

Location.—Halfway between Swan Lake and tidewater, on east shore of Carroll Inlet 1 mile from its head, 30 miles by water from Ketchikan.

Drainage area.—Not measured.

Records available.—August 24, 1916, to December 31, 1918.

Gage.—Stevens water-stage recorder on left bank, half a mile from tidewater; reached by a trail which leaves beach back of old cabin one-fourth mile south of mouth of creek. Gage was washed out by extreme high water in November, 1917. New gage installed 10 feet farther back in bank at old datum, but with a new control, on May 5, 1918.

Discharge measurements.—At medium and high stages, made from a cable across stream 100 feet downstream from gage; at low stages, made by wading.

Channel and control.—The gage well is in a deep pool 25 feet upstream from a contracted portion of the channel, where a fall of 1 foot over bedrock forms a permanent control. The effect of the violent fluctuation of the water surface outside of the gage well is decreased in the inner float well, because the intake holes at the bottom are very small. At the cable section the bed is rough, the water shallow, and the current very swift. Point of zero flow is at gage height −1.0 foot.

Extremes of discharge.—Maximum stage recorded during period May 5 to December 31, 4.82 feet at 3 a. m. November 30 (discharge, computed from extension of rating curve, 2,270 second-feet); minimum stage, 0.50 foot September 16 (discharge, 99 second-feet).

1915–1918: Maximum stage occurred probably on November 1, 1917 (discharge, estimated by comparison with Fish Creek, 5,500 second-feet); minimum discharge, 39 second-feet, April 2, 1917.

Ice.—Stage-discharge relation not affected by ice.

Accuracy.—Stage-discharge relation permanent. Rating curve, determined by four discharge measurements and point of zero flow, is fairly well defined below 2,000 second-feet. Water-stage recorder operated satisfactorily May 5 to December 31, 1918, except for short periods in December indicated in footnote to daily discharge table. No water-stage recorder graph from October 1, 1917, to May 5, 1918; mean monthly flow, estimated from record of flow at Fish Creek and ratios between mean monthly flow at Swan Lake Outlet and Fish Creek, obtained from a comparison of the data for these stations. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging discharges obtained by applying to rating table mean gage heights for regular intervals of day. Results good except for periods of break in record, for which they are fair.

Swan Lake, whose area is about 350 acres, is 1½ miles from tidewater, at an elevation of 225 feet.

*Discharge measurements of Swan Lake outlet at Carroll Inlet during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. |
|---|---|---|
| | *Feet.* | *Sec.-ft.* |
| Aug. 8 | 2.42 | 688 |
| Oct. 11 | 3.63 | 1,430 |
| 22 | 2.12 | 631 |

*Daily discharge, in second-feet, of Swan Lake outlet of Carroll Inlet for 1918.*

| Day. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| 1 | ........ | 603 | 644 | 440 | 288 | 176 | 1,380 | 1,860 |
| 2 | ........ | 492 | 540 | 350 | 227 | 160 | 930 | 1,320 |
| 3 | ........ | 460 | 436 | 291 | 190 | 480 | 598 | 820 |
| 4 | ........ | 488 | 374 | 255 | 166 | 1,510 | 406 | 1,050 |
| 5 | ........ | 572 | 346 | 212 | 145 | 2,140 | 309 | 368 |
| 6 | 990 | 675 | 354 | 197 | 133 | 1,420 | 792 | 306 |
| 7 | 720 | 760 | 385 | 388 | 122 | 919 | 770 | 279 |
| 8 | 608 | 902 | 420 | 730 | 109 | 960 | 562 | 244 |
| 9 | 612 | 990 | 460 | 720 | 104 | 684 | 440 | 207 |
| 10 | 666 | 1,170 | 468 | 666 | 145 | 980 | 343 | 194 |
| 11 | 760 | 1,320 | 562 | 468 | 151 | 1,580 | 270 | 178 |
| 12 | 740 | 1,140 | 662 | 350 | 141 | 2,100 | 402 | 162 |
| 13 | 652 | 930 | 612 | 270 | 126 | 1,617 | 577 | 151 |
| 14 | 666 | 820 | 520 | 220 | 116 | 960 | 300 | 139 |
| 15 | 698 | 720 | 468 | 185 | 108 | 580 | 360 | 135 |
| 16 | 698 | 720 | 448 | 197 | 101 | 388 | 285 | 202 |
| 17 | 597 | 770 | 440 | 300 | 131 | 326 | 235 | 279 |
| 18 | 512 | 795 | 420 | 291 | 188 | 406 | 194 | 300 |
| 19 | 452 | 698 | 402 | 585 | 190 | 562 | 166 | 309 |
| 20 | 406 | 594 | 368 | 1,260 | 180 | 1,260 | 153 | 244 |
| 21 | 378 | 562 | 326 | 875 | 155 | 898 | 372 | 247 |
| 22 | 368 | 504 | 291 | 1,080 | 137 | 612 | 820 | 183 |
| 23 | 342 | 504 | 267 | 1,410 | 135 | 440 | 960 | 190 |
| 24 | 332 | 562 | 248 | 902 | 137 | 374 | 770 | 244 |
| 25 | 357 | 621 | 255 | 648 | 290 | 385 | 608 | 285 |
| 26 | 432 | 702 | 264 | 512 | 711 | 619 | 760 | 616 |
| 27 | 520 | 735 | 288 | 492 | 540 | 1,680 | 652 | 532 |
| 28 | 919 | 621 | 594 | 662 | 374 | 1,350 | 562 | 402 |
| 29 | 1,350 | 532 | 585 | 644 | 276 | 1,050 | 1,290 | 300 |
| 30 | 1,050 | 524 | 520 | 500 | 214 | 1,230 | 2,060 | 222 |
| 31 | 795 | ........ | 440 | 374 | ........ | 1,470 | ........ | 190 |

NOTE.—Mean discharge, Oct. 1, 1917, to May 5, 1918, estimated, because of no gage-height graph, from a comparison of the records of flow for this station with those for Fish Creek as follows: Oct., 870 second-feet; November, 2.200 second-feet; December, 1917, 200 second-feet; January, 450 second-feet; February, 180 second-feet; March, 90 second-feet; April, 290 second-feet; May 1–5, 880 second-feet. Daily discharge estimated, because line drawn by pencil on gage-height graph was too faint to find, for following periods: Dec. 12–13, Dec. 19–24, Dec. 26–31, 1918.

*Monthly discharge of Swan Lake outlet at Carroll Inlet for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | ........ | ........ | 450 | 27,700 |
| February | ........ | ........ | 180 | 10,000 |
| March | ........ | ........ | 90 | 5,530 |
| April | ........ | ........ | 290 | 17,300 |
| May | 1,350 | 332 | 678 | 41,700 |
| June | 1,320 | 460 | 716 | 42,600 |
| July | 644 | 255 | 432 | 26,600 |
| August | 1,410 | 185 | 531 | 32,600 |
| September | 711 | 101 | 201 | 12,000 |
| October | 2,140 | 160 | 946 | 58,200 |
| November | 2,060 | 153 | 610 | 36,300 |
| December | 1,860 | 135 | 392 | 24,100 |
| The year | ........ | ........ | 462 | 335,000 |

NOTE.—See footnote to table of daily discharge.

## ORCHARD LAKE OUTLET AT SHRIMP BAY, REVILLAGIGEDO ISLAND.

LOCATION.—In latitude 55° 50′ N., longitude 131° 27′ W., at outlet of Orchard Lake, one-third mile from tidewater at head of Shrimp Bay, an arm of Behm Canal, 46 miles by water from Ketchikan.

DRAINAGE AREA.—Not measured.

Records available.—May 28, 1915, to December 31, 1918.

Gage.—Stevens water-stage recorder on right bank 300 feet below Orchard Lake and 100 feet above site of timber-crib dam, which was built in 1914 for proposed pulp mill and washed out by high water August 10, 1915. Datum of gage lowered 2 feet September 15, 1915. Gage heights May 29 to August 10 referred to first datum; August 11, 1915, to August 17, 1916, to second datum. Datum of gage lowered 1 foot August 17, 1916. Gage heights August 18 to December 31, 1916, referred to this datum. Gage washed out probably during high water on November 1, 1917. New gage installed on April 28, 1918, at old site at the datum of August 17, 1916.

Discharge measurements.—At medium and high stages made from cable 5 feet upstream from gage; at low stages by wading one-fourth mile below gage.

Channel and control.—From Orchard Lake, at elevation 134 feet above high tide, the stream descends in a series of rapids for 1,000 feet through a narrow gorge, then divides into two channels and enters the bay in two cascades of 100-foot vertical fall. Opposite the gage the water is deep and the current sluggish. At the site of the old dam bedrock is exposed, but for 30 feet upstream the channel is filled in with loose rock and brush placed during construction of dam. This material forms a riffle which acts as a control for water surface at gage at low and medium stages and is scoured down when ice goes out of lake; the rock outcrop at site of old dam acts as a control at high stages and is permanent.

Extremes of discharge.—Maximum stage recorded during period April 28 to December 31, 1918, 6.85 feet October 5 (discharge, 3,620 second-feet); minimum stage recorded, 0.58 foot September 17 (discharge, 110 second-feet).

1915–1918: Maximum stage occurred, probably, on November 1, 1917 (discharge estimated by multiplying maximum discharge at Fish Creek on that date by 1.55, which is the ratio between the maximum discharges of Orchard Lake outlet and Fish Creek on October 16 and 15, 1915, 7,100 second-feet); minimum discharge, estimated, 20 second-feet February 11, 1916.

Ice.—Stage-discharge relation not affected by ice.

Accuracy.—Stage-discharge relation changes occasionally during high water. Rating curve, determined by four discharge measurements made since new gage was installed, point of zero flow, and form of upper portion of old rating curve, is well defined below 4,000 second-feet. Water-stage recorder operating satisfactory April 28 to December 31, 1918. No water-stage recorder record from October 11, 1917, to April 27, 1918; mean monthly or part monthly flow estimated from record of flow at Fish Creek and ratios between mean monthly flows at Orchard Lake outlet and Fish Creek, obtained from a comparison of the data for these stations. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging discharges obtained by applying to rating table mean gage heights for regular intervals of day. Results good, except for period of break in record, for which they are fair.

The highest mountains on this drainage basin are only 3,500 feet above sea level and are covered to an elevation of 2,500 feet by a heavy stand of timber and a thick undergrowth of brush, ferns, alders, and devil's club. The topography is not so rugged as that of the area surrounding Shelockum Lake, and the proportion of vegetation, soil cover, and lake area is greater, so that more water is stored and the flow in the Orchard Lake drainage basin is better sustained.

*Discharge measurements of Orchard Lake outlet at Shrimp Bay during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. |
|---|---|---|
| | *Feet.* | *Sec-ft.* |
| Apr. 29 | 2.30 | 523 |
| Aug. 10 | 3.02 | 856 |
| Oct. 20 | 5.30 | 2,240 |

*Daily discharge, in second-feet, of Orchard Lake outlet at Shrimp Bay for 1918.*

| Day. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | 655 | 838 | 860 | 607 | 482 | 206 | 1,790 | 1,860 |
| 2 | | 635 | 695 | 735 | 522 | 361 | 176 | 1,080 | 1,520 |
| 3 | | 1,560 | 655 | 607 | 440 | 287 | 383 | 735 | 928 |
| 4 | | 1,900 | 735 | 526 | 393 | 232 | 1,950 | 512 | 611 |
| 5 | | 1,520 | 882 | 488 | 332 | 196 | 3,370 | 384 | 418 |
| 6 | | 1,160 | 1,020 | 530 | 294 | 170 | 1,860 | 662 | 329 |
| 7 | | 905 | 1,050 | 565 | 558 | 151 | 1,020 | 950 | 294 |
| 8 | | 838 | 1,160 | 613 | 1,050 | 135 | 860 | 635 | 268 |
| 9 | | 928 | 1,250 | 635 | 950 | 122 | 675 | 526 | 225 |
| 10 | | 978 | 1,340 | 655 | 795 | 120 | 1,130 | 421 | 204 |
| 11 | | 1,190 | 1,460 | 735 | 572 | 196 | 1,960 | 327 | 189 |
| 12 | | 928 | 1,310 | 882 | 430 | 211 | 2,930 | 443 | 160 |
| 13 | | 1,020 | 1,100 | 860 | 337 | 185 | 1,960 | 715 | 142 |
| 14 | | 1,050 | 1,050 | 715 | 280 | 160 | 1,050 | 588 | 132 |
| 15 | | 1,080 | 1,000 | 635 | 244 | 138 | 655 | 450 | 125 |
| 16 | | 1,100 | 1,020 | 607 | 218 | 122 | 440 | 358 | 204 |
| 17 | | 928 | 1,080 | 596 | 329 | 110 | 347 | 294 | 468 |
| 18 | | 838 | 1,100 | 558 | 358 | 147 | 393 | 244 | 592 |
| 19 | | 715 | 950 | 530 | 501 | 237 | 547 | 204 | 512 |
| 20 | | 655 | 860 | 462 | 2,010 | 237 | 2,000 | 176 | 273 |
| 21 | | 576 | 815 | 405 | 1,430 | 206 | 1,280 | 461 | 309 |
| 22 | | 554 | 735 | 378 | 978 | 170 | 815 | 978 | 251 |
| 23 | | 533 | 735 | 350 | 2,100 | 151 | 580 | 1,160 | 225 |
| 24 | | 554 | 775 | 324 | 1,400 | 179 | 466 | 905 | 273 |
| 25 | | 606 | 860 | 358 | 1,000 | 183 | 421 | 675 | 375 |
| 26 | | 735 | 928 | 396 | 1,020 | 675 | 884 | 860 | 719 |
| 27 | | 905 | 950 | 393 | 775 | 558 | 1,930 | 715 | 655 |
| 28 | 446 | 1,360 | 860 | 596 | 860 | 408 | 1,620 | 675 | 479 |
| 29 | 540 | 760 | 755 | 655 | 1,080 | 312 | 1,310 | 1,190 | 361 |
| 30 | 675 | 1,220 | 715 | 735 | 928 | 246 | 1,430 | 2,490 | 284 |
| 31 | | 1,020 | | 488 | 665 | | 2,010 | | 222 |

NOTE.—Mean discharge estimated, because of no gage record, from a comparison of the records of flow for this station with those of Fish Creek as follows: October, 11–31, 1,020 second-feet; November, 2,500 second-feet: December, 1917, 220 second-feet; Jannary, 525 second-feet; February, 200 second-feet; March, 90 second-feet; April, 1–27, 420 second-feet.

*Monthly discharge of Orchard Lake outlet at Shrimp Bay for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | | | 525 | 32,300 |
| February | | | 200 | 11,100 |
| March | | | 90 | 5,530 |
| April | | | 433 | 25,800 |
| May | 1,900 | 533 | 949 | 58,400 |
| June | 1,460 | 655 | 956 | 56,900 |
| July | 882 | 324 | 577 | 35,500 |
| August | 2,100 | 218 | 757 | 46,500 |
| September | 675 | 110 | 236 | 14,000 |
| October | 3,370 | 176 | 1,180 | 72,600 |
| November | 2,490 | 176 | 720 | 42,800 |
| December | 1,860 | 125 | 439 | 27,000 |
| The year | | | 592 | 428,000 |

NOTE.—See footnote to table of daily discharge.

### SHELOCKUM LAKE OUTLET AT BAILEY BAY.

LOCATION.—In latitude 56° 00′ N., longitude 131° 36′ W., on mainland near outlet of Shelockum Lake, three-fourths mile by Forest Service trail from tidewater at north end of Bailey Bay, and 52 miles by water north of Ketchikan.

DRAINAGE AREA.—18 square miles (measured on sheets Nos. 5 and 8 of the Alaska Boundary Tribunal, edition of 1895).

RECORDS AVAILABLE.—June 1, 1915, to December 31, 1918.

GAGE.—Stevens continuous water-stage recorder on right shore of lake, 250 feet above outlet. Gage house was pushed off the well by a snowslide January 4, 1917. Gage not put into operation again until May 23.

DISCHARGE MEASUREMENTS.—Made from cable across outlet of lake, 200 feet below gage and 50 feet upstream from crest of falls.

CHANNEL AND CONTROL.—Opposite the gage the lake is 600 feet wide; at the outlet bedrock is exposed and the water makes a nearly perpendicular fall of 150 feet. This fall forms an excellent and permanent control for the gage. At extremely high stages the lake has another outlet about 200 feet to left of main outlet. Point of zero flow is at gage height 0.6 foot.

EXTREMES OF DISCHARGE.—Maximum stage recorded during year, 4.92 feet, at 12.7 a. m. October 5 (discharge, 1,200 second-feet); minimum discharge (estimated from hydrograph for Fish Creek to have occurred March 13), 21 second-feet.

1915–1918: Maximum stage, 6.84 feet at 8 a. m. November 1, 1917 (discharge, 2,780 second-feet); minimum discharge, estimated from climatic records, 2.5 second-feet.

ICE.—Stage-discharge relation not affected by ice.

ACCURACY.—Stage-discharge relation permanent. Rating curve well defined. Operation of water-stage recorder satisfactory except for periods of break in record shown in the footnote to daily-discharge table. Daily discharge ascertained by applying to the rating table mean daily gage heights determined by inspection of gage-height graph, or, for days of considerable fluctuation, by averaging discharges obtained by applying to rating table mean gage heights for regular intervals of day. Results excellent, except for periods of break in record, for which they are fair.

Shelockum Lake, at an elevation of 344 feet, covers only 350 acres. The drainage basin above the lake is rough, precipitous, and covered with little soil or vegetation. There are no glaciers or ice fields at the source of the tributary streams. Therefore, because of little natural storage, the run-off after a heavy rainfall is rapid and not well sustained, and during a dry summer or winter the flow becomes very low. The large amount of snow that accumulates on the drainage basin during the winter maintains a good flow in May and June.

The following discharge measurement was made by G. H. Canfield:

August 10, 1918: Gage height, 3.04 feet; discharge, 330 second-feet.

*Daily discharge, in second-feet, of Shelockum Lake outlet of Bailey Bay for 1918.*

| Day. | Jan. | Feb. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 980 | 70 | ........ | 306 | 220 | 180 | 92 | 490 | ........ |
| 2 | 705 | 65 | ........ | 252 | 170 | 128 | 84 | 311 | ........ |
| 3 | 455 | 51 | ........ | 220 | 141 | 97 | 269 | 216 | ........ |
| 4 | 455 | 123 | ........ | 210 | 123 | 77 | 774 | 152 | ........ |
| 5 | 350 | ........ | ........ | 204 | 98 | 65 | 1,040 | 119 | ........ |
| 6 | 241 | ........ | ........ | 210 | 84 | 55 | 484 | 395 | 107 |
| 7 | 176 | ........ | ........ | 220 | 170 | 48 | 326 | 455 | 91 |
| 8 | 141 | ........ | ........ | 230 | 472 | 43 | 363 | ........ | 80 |
| 9 | 110 | ........ | ........ | 230 | 438 | 38 | 265 | ........ | 70 |
| 10 | 98 | ........ | ........ | 230 | 378 | 48 | 374 | ........ | 65 |
| 11 | 88 | ........ | ........ | 252 | 263 | 81 | 580 | ........ | 59 |
| 12 | 81 | ........ | ........ | 311 | 182 | 80 | 1,040 | ........ | 48 |
| 13 | 71 | ........ | ........ | 324 | 132 | 59 | 622 | ........ | 43 |
| 14 | 62 | ........ | ........ | 275 | 107 | 63 | 336 | ........ | 42 |
| 15 | 55 | ........ | ........ | 252 | 86 | 53 | 216 | ........ | 41 |
| 16 | 52 | ........ | ........ | 230 | 88 | 47 | 155 | ........ | 67 |
| 17 | 57 | ........ | ........ | 220 | 91 | 49 | 139 | ........ | 123 |
| 18 | 97 | ........ | 392 | 200 | 91 | 80 | 220 | ........ | 145 |
| 19 | 98 | ........ | 350 | 180 | 253 | 110 | 328 | ........ | 132 |
| 20 | 84 | ........ | 336 | 160 | 1,010 | 42 | 680 | ........ | 98 |
| 21 | 80 | ........ | 316 | 150 | 618 | 90 | 472 | ........ | 78 |
| 22 | 139 | ........ | 314 | 141 | 522 | 77 | 331 | ........ | 71 |
| 23 | 204 | ........ | 363 | 136 | 902 | 71 | 243 | ........ | 66 |
| 24 | 196 | ........ | 422 | 132 | 438 | 115 | 204 | ........ | 84 |
| 25 | 150 | ........ | 490 | 141 | 311 | 313 | 206 | ........ | 107 |
| 26 | 115 | ........ | 455 | 145 | 259 | 660 | 426 | ........ | 180 |
| 27 | 98 | ........ | 378 | 160 | 252 | 378 | 705 | ........ | 150 |
| 28 | 92 | ........ | 324 | 210 | 490 | 239 | 600 | ........ | 115 |
| 29 | 86 | ........ | 311 | 210 | 542 | 162 | 525 | ........ | 87 |
| 30 | 80 | ........ | 392 | 180 | 392 | 119 | 525 | ........ | 65 |
| 31 | 75 | | ........ | 190 | 256 | ........ | 542 | ........ | 51 |

NOTE.—Jan. 28 to Feb. 1, discharge interpolated. Feb. 5 to June 17, mean discharge estimated, because of no record except maximum and minimum stages indicated by the recorder and gage reading on Apr. 27, from record of flow at Fish Creek and ratios, between mean monthly discharges at Fish Creek and Shelockum Lake outlet, obtained from a comparison of the record for these stations as follows: Feb. 5–28, 65 second-feet; March, 42 second-feet; April, 132 second-feet; May, 310 second-feet; June 1–17, 420 second-feet; July 4 to Aug. 10, daily discharge estimated, because of supply of paper on recorder running out on July. 3, from a gage-height graph drawn by comparison with that for Orchard Lake outlet through maximum and minimum stages indicated by recorder at Shelockum Lake. Nov. 8 to Dec. 5, discharge estimated, because of no record due to catching of float, from record of flow at Fish Creek and ratios obtained from a comparison of the record for these stations, as follows: Nov. 8–30, 200 second-feet; Dec. 1–5, 320 second-feet.

*Monthly discharge of Shelockum Lake outlet at Bailey Bay for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 980 | 52 | 186 | 11,400 |
| February | ........ | ........ | 67 | 3,720 |
| March | ........ | ........ | 42 | 2,580 |
| April | ........ | ........ | 132 | 7,860 |
| May | ........ | ........ | 310 | 19,100 |
| June | ........ | ........ | 405 | 24,100 |
| July | 324 | 132 | 210 | 12,900 |
| August | 1,010 | 84 | 309 | 19,000 |
| September | 660 | 38 | 122 | 7,260 |
| October | 1,040 | 84 | 425 | 26,100 |
| November | ........ | ........ | 231 | 13,700 |
| December | ........ | 41 | 125 | 7,690 |
| The year | ........ | ........ | 214 | 155,000 |

NOTE.—See footnote to table of daily discharge.

### KARTA RIVER AT KARTA BAY, PRINCE OF WALES ISLAND.

Location.—In latitude 55° 34′ N., longitude 132° 37′ W., at head of Karta Bay, an arm of Kasaan Bay, on east coast of Prince of Wales Island, 42 miles by water across Clarence Strait from Ketchikan.

Drainage area.—49.5 square miles (U. S. Forest Service reconnaissance map of Prince of Wales Island, 1914).

Records available.—July 1, 1915, to December 31, 1917.

Gage.—Stevens continuous water-stage recorder on left bank, half a mile above tidewater, at head of Karta Bay and 1¼ miles below outlet of Little Salmon Lake. Two per cent of total drainage of Karta River enters between outlet of lake and gage.

Discharge measurements.—At medium and high stages made from cable across river 50 feet upstream from gage; at low stages by wading at cable section.

Channel and control.—From Little Salmon Lake, 1½ miles from tidewater, the river descends 105 feet in a series of rapids in a wide, shallow channel, the banks of which are low but do not overflow. The bed is of coarse gravel and boulders; rock crops out only at outlet of lake. Gage and cable are at a pool of still water formed by a riffle of coarse gravel that makes a well-defined and permanent control.

Extremes of discharge.—Maximum stage recorded during the year, 4.1 feet at 12 p. m. December 1 (discharge computed from an extension of the rating curve, 2,960 second-feet); minimum stage, 0.91 foot, March 12 (discharge, 66 second-feet).

1915–1918: Maximum stage, 5.5 feet November 1, 1917 (discharge, 5,070 second-feet); minimum flow, 21 second-feet, February 11, 1915.

Accuracy.—Stage-discharge relation permanent. Rating curve well defined between 80 and 1,500 second-feet; extended below 80 second-feet to the point of zero flow and above 1,500 second-feet by estimation. Operation of water-stage recorder satisfactory except for periods indicated by breaks in record as shown in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying gage heights for regular intervals to rating table. Results excellent except for periods of break in record, for period affected by ice, and for discharges above 1,500 second-feet, for which they are fair.

The combined area of Little Salmon Lake at elevation 105 feet, and Salmon Lake at elevation 110 feet, is 1,600 acres. The slopes along the right shore of lakes and at head of Salmon Lake are gentle, and the area included by the 250-foot contour above lake outlet is 5,500 acres. The drainage area to elevation 2,000 feet is heavily covered with timber and dense undergrowth of ferns, brush, and alders. The upper parts of the mountains are covered with thin soil and brush. Only a few peaks at an elevation of 3,500 feet are bare. This large lake and flat area and thick vegetal cover affords considerable natural storage, which, after heavy precipitation, maintains a good run-off. The snow usually melts by the end of June, and the run-off becomes very low during a dry, hot summer.

The Forest Service in the summer of 1916 constructed a pack trail from tidewater to outlet of Little Salmon Lake.

*Daily discharge, in second-feet, of Karta River at Karta Bay for 1918.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2,620 | 280 | 135 | 210 | 536 | 681 | 332 | 112 | 243 | 290 | 1,940 | 2,560 |
| 2 | 2,060 | 264 | 149 | 188 | 572 | 588 | 314 | 112 | 201 | 233 | 1,300 | 2,030 |
| 3 | 1,820 | 597 | 135 | 184 | 1,130 | 536 | 290 | 112 | 180 | 224 | 1,020 | 1,320 |
| 4 | 1,700 | 1,330 | 118 | 206 | 1,380 | 529 | 264 | 103 | 152 | 719 | 722 | 862 |
| 5 | 1,240 | 1,020 | 112 | 192 | 1,280 | 580 | 248 | 97 | 176 | 1,390 | 536 | 595 |
| 6 | 916 | 764 | 103 | 168 | 1,050 | 665 | 238 | 94 | 115 | 916 | 1,220 | 467 |
| 7 | 681 | 618 | 97 | 156 | 862 | 730 | 233 | 152 | 106 | 697 | 1,380 | 474 |
| 8 | 522 | 572 | 88 | 264 | 790 | 853 | 229 | 229 | 94 | 730 | 1,000 | 350 |
| 9 | 441 | 529 | 81 | 610 | 817 | 952 | 224 | 264 | 86 | 617 | 862 | 290 |
| 10 | 382 | 480 | 74 | 756 | 880 | 943 | 224 | 308 | 86 | 705 | 625 | 274 |
| 11 | 415 | 540 | 69 | 773 | 980 | 862 | 220 | 290 | 112 | 1,060 | 480 | 238 |
| 12 | 454 | 360 | 66 | 705 | 990 | 773 | 229 | 254 | 115 | 1,510 | 508 | 206 |
| 13 | 415 | 290 | 76 | 641 | 889 | 705 | 238 | 229 | 106 | 1,150 | 633 | 180 |
| 14 | 402 | 243 | 83 | 550 | 880 | 665 | 229 | 254 | 97 | 773 | 603 | 172 |
| 15 | 376 | 224 | 83 | 487 | 889 | 625 | 220 | 238 | 88 | 565 | 522 | 160 |
| 16 | 415 | 192 | 86 | 441 | 862 | 610 | 197 | 206 | 81 | 428 | 415 | 304 |
| 17 | 952 | 168 | 86 | 395 | 764 | 610 | 188 | 184 | 78 | 494 | 338 | 501 |
| 18 | 1,020 | 152 | 86 | 690 | 681 | 610 | 180 | 168 | 88 | 657 | 280 | 649 |
| 19 | 773 | 138 | 83 | 1,580 | 588 | 543 | 172 | 180 | 115 | 757 | 238 | 657 |
| 20 | 602 | 128 | 100 | 1,320 | 543 | 487 | 184 | 565 | 118 | 1,520 | 206 | 543 |
| 21 | 641 | 118 | 115 | 990 | 501 | 434 | 152 | 673 | 112 | 1,270 | 302 | 402 |
| 22 | 970 | 115 | 130 | 782 | 474 | 402 | 145 | 580 | 106 | 980 | 748 | 396 |
| 23 | 1,200 | 109 | 140 | 705 | 441 | 382 | 132 | 722 | 97 | 730 | 907 | 434 |
| 24 | 1,140 | 109 | 150 | 625 | 441 | 396 | 125 | 649 | 103 | 625 | 844 | 588 |
| 25 | 871 | 109 | 150 | 550 | 474 | 402 | 118 | 522 | 372 | 572 | 853 | 657 |
| 26 | 714 | 109 | 143 | 508 | 550 | 408 | 115 | 454 | 1,270 | 808 | 1,150 | 1,070 |
| 27 | 641 | 106 | 140 | 480 | 641 | 415 | 112 | 382 | 1,010 | 1,060 | 1,170 | 925 |
| 28 | 543 | 118 | 180 | 480 | 1,070 | 389 | 109 | 363 | 697 | 1,080 | 1,040 | 681 |
| 29 | 441 | ........ | 220 | 529 | 1,220 | 363 | 109 | 363 | 501 | 1,120 | 1,560 | 501 |
| 30 | 363 | ........ | 240 | 565 | 1,020 | 338 | 109 | 332 | 376 | 1,350 | 1,880 | 363 |
| 31 | 314 | ........ | 240 | ........ | 840 | ........ | 109 | 285 | ........ | 1,820 | ........ | 290 |

NOTE.—Discharge Feb. 11-13, Mar. 20 to Apr. 1, and Dec. 29-31 estimated, because of clock stopping, from maximum and minimum stages indicated by the recorder and from a comparison of the hydrograph for this station with the climatic data for Ketchikan and the hydrograph for Fish Creek.

*Monthly discharge of Karta River at Karta Bay for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 2,620 | 314 | 839 | 51,600 |
| February | 1,330 | 106 | 349 | 19,400 |
| March | 240 | 66 | 121 | 7,440 |
| April | 1,580 | 184 | 224 | 13,300 |
| May | 1,380 | 441 | 808 | 49,700 |
| June | 952 | 338 | 583 | 34,700 |
| July | 332 | 109 | 193 | 11,900 |
| August | 722 | 94 | 306 | 18,800 |
| September | 1,270 | 78 | 236 | 14,000 |
| October | 1,820 | 224 | 866 | 53,200 |
| November | 1,940 | 206 | 843 | 50,200 |
| December | 2,560 | 160 | 617 | 38,000 |
| The year | 2,620 | 66 | 499 | 362,000 |

NOTE.—See footnote to table of daily discharge.

### CASCADE CREEK AT THOMAS BAY NEAR PETERSBURG.

LOCATION.—One-fourth mile above tidewater on each shore of south arm of Thomas Bay; 22 miles by water from Petersburg. One small tributary enters the river from the left half a mile above gage and 2 miles below lake outlet.

DRAINAGE AREA.—21.4 square miles (measured on the United States Geological Survey geologic reconnaissance map of the Wrangell mining district, edition of 1907).

Records available.—October 27, 1917, to December 31, 1918.

Gage.—Stevens water-stage recorder on left bank, one-fourth mile from tidewater; reached by trail which leaves beach back of old cabin at mouth of creek.

Discharge measurements.—At medium and high stages, made from log footbridge across stream one-fourth mile upstream from gage; at low stages, made by wading.

Channel and control.—From the outlet of a lake at an elevation of 1,200 feet above sea level and 3 miles from tidewater the river descends in a continuous series of rapids and falls through a narrow, deep canyon. Gage is in a protected eddy above a natural rock weir, which forms a well-defined and permanent control. The bed of river under the footbridge is rough and the current swift and irregular, but this section is the only place on the whole river where even at low and medium stages there are no boils and eddies.

Extremes of stage.—Maximum stage recorded during period, 7.65 feet at 11 p. m. November 18, 1917 (discharge computed from extension of rating curve, 1,980 second-feet); minimum stage, 0.80 foot about April 6, 1918 (discharge, 17 second-feet).

Ice.—Stage-discharge relation not affected by ice.

Accuracy.—Stage-discharge relation permanent. Rating curve well defined below 1,200 second-feet. Operation of water-stage recorder satisfactory except for periods indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging discharge for equal intervals of day. Results good except for periods when recorder did not operate satisfactorily, for which they are fair.

The first site on this stream for a storage reservoir is at a small lake 3 miles from tidewater, at an elevation of 1,200 feet above sea level. The drainage area above the gaging station is 21 square miles and above the lake outlet 17 square miles. Flow during summer is augmented by melting ice from glaciers on upper portion of drainage area.

*Discharge measurements of Cascade Creek at Thomas Bay during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| Mar. 6 | a 1.13 | 24 | Aug. 15 | 3.82 | 325 |
| May 27 | 3.46 | 223 | Oct. 5 | 5.66 | 943 |

a Ice on control but apparently bridged over.

*Daily discharge, in second-feet, of Cascade Creek at Thomas Bay for 1917–18.*

| Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. | Day. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1917. | | | | 1917. | | | | 1917. | | | |
| 1 | | 955 | 128 | 11 | | 552 | 84 | 21 | | 910 | |
| 2 | | 1,370 | 116 | 12 | | 518 | 77 | 22 | | 692 | |
| 3 | | 658 | 104 | 13 | | 772 | 73 | 23 | | 518 | |
| 4 | | 425 | 93 | 14 | | 1,470 | 70 | 24 | | 355 | |
| 5 | | 368 | 87 | 15 | | 1,020 | | 25 | | 280 | |
| 6 | | 410 | 84 | 16 | | 640 | | 26 | | 260 | |
| 7 | | 588 | 83 | 17 | | 752 | | 27 | 140 | 270 | |
| 8 | | 410 | 99 | 18 | | 1,060 | | 28 | 220 | 210 | |
| 9 | | 305 | 96 | 19 | | 1,720 | | 29 | 183 | 175 | |
| 10 | | 535 | 88 | 20 | | 1,370 | | 30 | 304 | 144 | |
| | | | | | | | | 31 | 518 | | |

*Daily discharge, in second-feet, of Cascade Creek at Thomas Bay for 1917–18*—Continued.

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1918. | | | | | | | | | | | | |
| 1 | ...... | 37 | ...... | 19 | ...... | 270 | 318 | 440 | 518 | 292 | 305 | 270 |
| 2 | ...... | 36 | ...... | 19 | ...... | 220 | 368 | 395 | 410 | 318 | 210 | 240 |
| 3 | ...... | 54 | ...... | 19 | ...... | 230 | 305 | 380 | 330 | 552 | 160 | 175 |
| 4 | ...... | 48 | ...... | ...... | ...... | 240 | 280 | 355 | 270 | 1,000 | 129 | 119 |
| 5 | ...... | 42 | ...... | ...... | ...... | 280 | 292 | 342 | 250 | 955 | 383 | 104 |
| 6 | ...... | 40 | 24 | ...... | ...... | 330 | 368 | 425 | 220 | 640 | 393 | 94 |
| 7 | 97 | 40 | 22 | ...... | ...... | 368 | 470 | 455 | 200 | 470 | 260 | 90 |
| 8 | 84 | 40 | 22 | ...... | ...... | 425 | 535 | 410 | 200 | 455 | 200 | 81 |
| 9 | 71 | 39 | 21 | ...... | ...... | 455 | 605 | 410 | 183 | 368 | 153 | 72 |
| 10 | 64 | 38 | 20 | ...... | ...... | 500 | 640 | 395 | 318 | 380 | 127 | 66 |
| 11 | 62 | ...... | 20 | ...... | ...... | 640 | 622 | 342 | 485 | 355 | 117 | 60 |
| 12 | 60 | ...... | 20 | ...... | ...... | 570 | 570 | 318 | 260 | 455 | 117 | 57 |
| 13 | 56 | ...... | 20 | ...... | ...... | 500 | 500 | 292 | 200 | 410 | 104 | 54 |
| 14 | 53 | ...... | 20 | ...... | ...... | 500 | 500 | 305 | 175 | 292 | 93 | 60 |
| 15 | 51 | ...... | 20 | ...... | ...... | 535 | 552 | 305 | 192 | 220 | 83 | 60 |
| 16 | 49 | ...... | 20 | ...... | ...... | 552 | 658 | 462 | 230 | 167 | 74 | ...... |
| 17 | 50 | ...... | 20 | ...... | ...... | 605 | 750 | 500 | 379 | 230 | 69 | ...... |
| 18 | 48 | ...... | 20 | ...... | ...... | 605 | 770 | 425 | 710 | 260 | 65 | ...... |
| 19 | 45 | ...... | 20 | ...... | ...... | 535 | 770 | 734 | 570 | 260 | 69 | ...... |
| 20 | 42 | ...... | 20 | ...... | ...... | 485 | 692 | 1,470 | 380 | 330 | 248 | ...... |
| 21 | 53 | ...... | 20 | ...... | ...... | 470 | 622 | 1,180 | 260 | 260 | 330 | ...... |
| 22 | 60 | ...... | 20 | ...... | ...... | 455 | 552 | 980 | 192 | 200 | 330 | ...... |
| 23 | 58 | ...... | 19 | ...... | ...... | 470 | 500 | 1,470 | 260 | 167 | 292 | ...... |
| 24 | 52 | ...... | 19 | ...... | ...... | 552 | 470 | 1,270 | 260 | 148 | 250 | ...... |
| 25 | 48 | ...... | 19 | ...... | ...... | 675 | 455 | 830 | 780 | 183 | 200 | ...... |
| 26 | 46 | ...... | 19 | ...... | ...... | 675 | 440 | 605 | 1,300 | 280 | 160 | ...... |
| 27 | 46 | ...... | 19 | ...... | ...... | 640 | 500 | 734 | 980 | 368 | 134 | ...... |
| 28 | 44 | ...... | 19 | 125 | ...... | 588 | 710 | 1,220 | 658 | 355 | 119 | ...... |
| 29 | 42 | ...... | 19 | ...... | ...... | 552 | 640 | 1,200 | 470 | 330 | 134 | ...... |
| 30 | 39 | ...... | 19 | ...... | ...... | 552 | 535 | 955 | 355 | 518 | 240 | ...... |
| 31 | 38 | ...... | 19 | ...... | 342 | ...... | 500 | 710 | ...... | 440 | ...... | ...... |

NOTE.—Discharge estimated for following periods because of unsatisfactory operation of water-stage recorder: Dec. 15–31, 1917 (mean discharge, 65 second-feet), by comparison with record of flow for Long River at Port Snettisham; Jan. 1–6 (mean discharge, 114 second-feet), Feb. 11–28 (mean discharge, 24 second-feet), Mar. 1–5 (mean discharge, 22 second-feet), Mar. 7–9 and Apr. 4–30 (mean discharge, 54 second-feet) by comparison with hydrograph for Long River and climatic records for Juneau; May 1–30 (mean discharge, 190 second-feet) by comparison with records of flow for Long River; Oct. 3–4 and Nov. 24 to Dec. 6 from hydrograph drawn by comparison with that for Sweetheart Falls Creek through maximum and minimum stages indicated by recorder; Dec. 16–31, 1918 (mean discharge, 82 second-feet), by comparison with records of flow for Long River.

*Monthly discharge of Cascade Creek at Thomas Bay for 1917–18.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| 1917. | | | | |
| November | 1,720 | 144 | 657 | 39,100 |
| December | 128 | ...... | 73.8 | 4,540 |
| 1918. | | | | |
| January | ...... | 38 | 65.9 | 4,050 |
| February | 54 | ...... | 27.3 | 1,520 |
| March | 24 | 19 | 20.3 | 1,250 |
| April | ...... | 18 | 50.5 | 3,000 |
| May | ...... | ...... | 195 | 12,000 |
| June | 675 | 220 | 482 | 28,700 |
| July | 770 | 280 | 532 | 32,700 |
| August | 1,470 | 292 | 656 | 40,300 |
| September | 1,300 | 175 | 400 | 23,800 |
| October | 1,000 | 148 | 376 | 23,100 |
| November | 383 | 65 | 185 | 11,000 |
| December | 270 | ...... | 90.8 | 5,580 |
| The year | 1,470 | 18 | 257 | 187,000 |

NOTE.—See footnote to table of daily discharge.

### GREEN LAKE OUTLET AT SILVER BAY, NEAR SITKA.

Location.—In latitude 56° 59′ N., longitude 135° 5′ W., at outlet of Green Lake, head of Silver Bay, 10½ miles by water south of Sitka.

Drainage area.—Not measured.

Records available.—August 22, 1915, to December 31, 1918.

Gage.—Stevens water-stage recorder on right bank, at outlet of lake, reached by trail which leaves the beach one-fourth mile north of mouth of stream, ascends a 600-foot ridge, and then drops down to the outlet of the lake. Gage datum lowered 1 foot December 27, 1916.

Discharge measurements.—Made from cable across outlet 30 feet below gage.

Channel and control.—From Green Lake, 240 feet above sea level and 1,800 feet from tidewater, the stream descends in a series of falls and rapids through a narrow canyon whose exposed rock walls rise vertically more than 100 feet.

Extremes of discharge.—Maximum stage during period, from water-stage recorder, 130 feet, September 26, 1918 (discharge, estimated from extension of rating curve 3,300 second-feet); minimum stage recorded, 0.01 foot, March 27–28, 1918 (discharge, 11 second-feet).

Ice.—Ice forms on lake and at gage, but because of current and flow of relatively warm weather from the lake the control remains open.

Accuracy.—Stage-discharge relation permanent. Rating curve well defined between 10 and 1,300 second-feet. Operation of water-stage recorder satisfactory except for periods indicated by breaks in record, as shown in the footnote to the daily-discharge table. Daily discharge ascertained by applying to the rating table mean daily gage height, determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table gage heights for regular intervals of day. Records good, except those for periods when gage was not operating satisfactorily, which are fair.

In the fall and winter the flow is low because there is little ground storage, and on most of the drainage area the precipitation is in the form of snow. This accumulated snow produces a large run-off during the spring, and the melting ice from the glacier and the ice-capped mountains augments the run-off from precipitation during the summer. The area of Green Lake is estimated to be only 100 acres.

*Daily discharge, in second-feet, of Green Lake outlet at Silver Bay for 1918.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 328 | 42 | 33 | 18 | 87 | 303 | | 406 | | | |
| 2 | 424 | 41 | 34 | 14 | 110 | 286 | | 354 | | | |
| 3 | 320 | 42 | 29 | 24 | 254 | 270 | | 328 | | | |
| 4 | 270 | 65 | 25 | 30 | 346 | 354 | | 354 | | | |
| 5 | 188 | 65 | 22 | 19 | 294 | 461 | | 337 | 662 | | |
| 6 | 130 | 53 | 23 | 14 | 226 | 578 | | 371 | | | |
| 7 | 100 | 44 | 23 | 13 | 182 | 728 | 706 | 518 | | | |
| 8 | 81 | 46 | 19 | 14 | 188 | 889 | 774 | 490 | | | |
| 9 | 73 | | 18 | 23 | 247 | 797 | 820 | 406 | | | |
| 10 | 70 | | 20 | 28 | 312 | 700 | 728 | 415 | | | |
| 11 | 66 | | 20 | 39 | 406 | 610 | 684 | 380 | | | |
| 12 | 63 | | 18 | 44 | 397 | 557 | 684 | 328 | | | |
| 13 | 60 | | 15 | 60 | 320 | 547 | 547 | 380 | | 152 | |
| 14 | 55 | | 14 | 54 | 286 | | 599 | 406 | | 166 | 64 |
| 15 | 49 | | 13 | 52 | 262 | | 695 | 354 | | 156 | 64 |
| 16 | 46 | | 13 | 50 | 303 | | 774 | 461 | | 147 | 69 |
| 17 | 48 | | 14 | 47 | | | 820 | 470 | | | 80 |
| 18 | 62 | 28 | 14 | 111 | | | 843 | 354 | | | 95 |
| 19 | 59 | 26 | 15 | 346 | | | 820 | 354 | | | 94 |
| 20 | 51 | 26 | 14 | 270 | | | 751 | 557 | | | 80 |
| 21 | 51 | 28 | 14 | 161 | | | 620 | 557 | | | 81 |
| 22 | 191 | 38 | 14 | 116 | | | 528 | 499 | | | 194 |
| 23 | 270 | 33 | 15 | 114 | | | 490 | 866 | | | 223 |
| 24 | 247 | 30 | 13 | 106 | | | 442 | | | | 286 |
| 25 | 166 | 36 | 12 | 86 | | | 452 | | | | 233 |
| 26 | 120 | 37 | 12 | 79 | | | 461 | | | | 328 |
| 27 | 106 | 30 | 11 | 79 | | | 490 | | | | 182 |
| 28 | 85 | 28 | 11 | 76 | | | 578 | | | | 118 |
| 29 | 63 | | 12 | 81 | | | 490 | | | | 90 |
| 30 | 54 | | 25 | 89 | | | 424 | | | | 80 |
| 31 | 47 | | 24 | | | | 406 | | | | 73 |

NOTE.—Discharge estimated for the following periods because of unsatisfactory operation of water-stage recorder: Jan. 8–12 and Feb. 9–17 (mean discharge, 44 second-feet), by comparison with hydrograph for Baranof Lake outlet at Warm Spring Bay and climatic data at Sitka; June 10, discharge interpolated: May 17–31 (mean discharge, 330 second-feet), June 14–30 (mean discharge, 610 second-feet), July 1–6 (mean discharge, 510 second-feet), Aug. 24–31 (mean discharge, 650 second-feet), Sept. 1–24 (mean discharge, 340 second-feet), Sept. 25–30 (mean discharge, 1,100 second-feet), Oct. 1–31 (mean discharge, 420 second-feet), Nov. 1–12 (mean discharge, 520 second-feet), Nov. 17–30 (mean discharge, 320 second-feet), and Dec. 1–13 (mean discharge, 190 second-feet), by maximum and minimum stages indicated by recorder and by comparison with record of flow for Baranof Lake outlet.

*Monthly discharge of Green Lake outlet at Silver Bay for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 428 | 46 | 127 | 7,810 |
| February | 65 | 26 | 40.0 | 2,220 |
| March | 34 | 11 | 18.0 | 1,110 |
| April | 346 | 13 | 75.2 | 4,470 |
| May | | 87 | 296 | 18,200 |
| June | 889 | | 582 | 34,600 |
| July | 843 | | 600 | 36,900 |
| August | | 354 | 489 | 30,100 |
| September | | | 492 | 29,300 |
| October | | | 420 | 25,800 |
| November | | | 378 | 22,500 |
| December | | 64 | 190 | 11,700 |
| The year | | 11 | 309 | 225,000 |

NOTE.—See footnote to table of daily discharge.

### BARANOF LAKE OUTLET AT BARANOF, BARANOF ISLAND.

LOCATION.—In latitude 57° 5′ N., longitude 134° 54′ W., at townsite of Baranof, at head of Warm Spring Bay, east coast of Baranof Island, 18 miles east of Sitka across island, but 96 miles from Sitka by water through Peril Strait.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—June 28, 1915, to December 31, 1918.

GAGE.—Stevens water-stage recorder on right bank 700 feet below Baranof Lake and 800 feet above tidewater at head of Warm Spring Bay.

DISCHARGE MEASUREMENTS.—At medium and high stages, from cable across stream 100 feet below lake and 600 feet above gage; at low stages, by wading 100 feet below cable.

CHANNEL AND CONTROL.—From Baranof Lake, at elevation 130 feet above sea level and 1,500 feet from tidewater, the stream descends in a series of rapids and small falls and enters the bay in a cascade of about 100 feet concentrated fall. The bed is of glacial drift, boulders, and rock outcrop. The gage is in an eddy 50 feet downstream from the foot of a small fall and 100 feet upstream from a riffle which forms a well-defined control.

EXTREMES OF DISCHARGE.—Maximum stage recorded during year, 5 feet at 10 p. m., September 26 (discharge, computed from an extension of rating curve, 2,920 second-feet); minimum, 0.40 foot, March 20–22 (discharge, 30 second-feet).

1915–1918: Maximum stage recorded during period, 5.3 feet August 10, 1915 (discharge, computed from extension of rating curve, 3,350 second-feet); minimum flow, estimated by discharge measurement and climatic data, 28 second-feet, February 13, 1915.

ICE.—Because of the swift current and flow of relatively warm water from the lake, the stream remains open.

DIVERSIONS.—The flume to Olsen's sawmill diverts from the stream 200 feet below gage only sufficient water to operate a 25-horsepower Pelton water wheel.

ACCURACY.—Stage-discharge relation permanent, not affected by ice. Rating curve well defined below 2,000 second-feet. Operation of water-stage recorder satisfactory except for periods indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging discharge for equal intervals of day. Results good except for periods when recorder did not operate satisfactorily and for periods when water was frozen in well, for which they are fair.

The drainage area is rough and precipitous, and the vegetable and soil cover is thin, even on the foothills of the mountains. The run-off is rapid, and the ground storage is small. During a hot, dry period, however, the flow is greatly augmented by melting ice from several small glaciers and ice-capped mountains.

*Discharge measurements of Baranof Lake outlet at Baranof during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. |
|---|---|---|
| | *Feet.* | *Sec.-ft.* |
| Mar. 18 | 0.44 | 30 |
| Dec. 10 | 1.21 | 125 |

*Daily discharge, in second-feet, of Baranof Lake outlet at Baranof for 1918.*

| Day. | Jan. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ........ | ........ | 36 | 147 | 568 | 855 | 668 | 820 | 432 | 1,010 | 930 |
| 2 | ........ | ........ | 34 | 167 | 545 | 855 | 615 | 668 | 384 | 590 | 788 |
| 3 | ........ | ........ | 36 | 245 | 545 | 820 | 615 | 545 | 545 | 460 | 492 |
| 4 | ........ | 45 | 36 | 362 | 590 | 788 | 615 | 480 | 1,540 | 333 | 336 |
| 5 | ........ | ........ | 36 | 400 | 640 | 725 | 615 | 480 | 1,010 | 780 | 255 |
| 6 | ........ | ........ | 32 | 348 | 755 | 890 | 615 | 392 | 640 | 2,250 | 218 |
| 7 | ........ | ........ | 30 | 309 | 890 | 1,100 | 755 | 356 | 568 | 1,140 | 195 |
| 8 | ........ | ........ | 36 | 300 | 1,230 | 1,180 | 725 | 333 | 640 | 725 | 167 |
| 9 | ........ | ........ | 53 | 324 | 1,140 | 1,230 | 695 | 318 | 545 | 545 | 145 |
| 10 | ........ | ........ | 83 | 384 | 1,050 | 1,230 | 725 | 400 | 890 | 380 | 131 |
| 11 | ........ | ........ | 98 | 484 | 1,010 | 1,180 | 668 | 522 | 1,230 | 297 | 114 |
| 12 | ........ | ........ | 107 | 545 | 930 | 1,050 | 615 | 448 | 1,430 | 261 | 107 |
| 13 | ........ | ........ | 122 | 568 | 855 | 890 | 640 | 362 | 1,010 | 253 | 106 |
| 14 | ........ | ........ | 116 | 522 | 890 | 930 | 640 | 315 | 640 | 228 | 104 |
| 15 | ........ | ........ | 102 | 500 | 1,010 | 1,050 | 640 | 312 | 456 | 203 | 104 |
| 16 | ........ | ........ | 106 | 488 | 1,010 | 1,180 | 695 | 356 | 345 | 191 | 104 |
| 17 | ........ | ........ | 101 | 436 | 1,010 | 1,280 | 640 | 900 | 339 | 169 | 104 |
| 18 | ........ | 33 | 127 | 404 | 1,010 | 1,380 | 568 | 1,880 | 432 | 145 | ........ |
| 19 | 76 | 32 | 147 | 366 | 970 | 1,330 | 568 | 1,330 | 500 | 125 | ........ |
| 20 | 73 | 30 | 155 | 345 | 890 | 1,180 | 725 | 788 | 440 | 118 | ........ |
| 21 | 72 | 30 | 151 | 327 | 890 | 1,050 | 725 | 522 | 370 | 195 | ........ |
| 22 | 98 | 30 | 143 | 324 | 890 | 970 | 695 | 380 | 300 | 522 | ........ |
| 23 | 139 | 32 | 151 | 339 | 855 | 930 | 890 | 330 | 261 | 1,050 | ........ |
| 24 | 155 | 32 | 151 | 362 | 930 | 820 | 1,140 | 309 | 252 | 1,180 | ........ |
| 25 | 145 | 34 | 141 | 370 | 970 | 820 | 855 | 1,090 | 245 | 755 | ........ |
| 26 | 145 | 38 | 135 | 436 | 855 | 820 | 668 | 2,510 | 338 | 640 | ........ |
| 27 | 135 | 35 | 129 | 522 | 820 | 788 | 750 | 2,130 | 615 | 492 | ........ |
| 28 | 122 | 35 | 127 | 755 | 890 | 855 | 1,180 | 1,100 | 640 | 400 | ........ |
| 29 | ........ | 37 | 131 | 930 | 890 | 755 | 1,330 | 725 | 668 | 408 | ........ |
| 30 | ........ | 39 | 141 | 820 | 855 | 725 | 1,540 | 545 | 1,340 | 640 | ........ |
| 31 | ........ | 40 | ........ | 668 | ........ | 725 | 1,140 | ........ | 1,880 | ........ | |

NOTE.—Discharge estimated for the following periods, because of unsatisfactory operation of water-stage recorder: Jan. 1–18 (mean discharge, 140 second-feet), Feb. 1–28 (mean discharge, 66 second-feet), and Mar. 1–17 (mean discharge, 66 second-feet) by comparison with record of flow for Green Lake outlet; Silver Bay, from climatic records at Sitka, and from staff gage reading, 0.58 foot, Mar. 4; Dec. 18–31 (mean discharge, 150 second-feet) by comparison with record of flow for Sweetheart Falls near Snettisham.

*Monthly discharge of Baranof Lake outlet at Baranof for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | ............ | ............ | 129 | 7,930 |
| February | ............ | ............ | 66 | 3,670 |
| March | ............ | 30 | 51.6 | 3,170 |
| April | 155 | 30 | 99.8 | 5,940 |
| May | 930 | 147 | 436 | 26,800 |
| June | 1,230 | 545 | 879 | 52,300 |
| July | 1,380 | 725 | 980 | 60,300 |
| August | 1,540 | 568 | 773 | 47,500 |
| September | 2,510 | 312 | 722 | 43,000 |
| October | 1,880 | 245 | 675 | 41,500 |
| November | 2,250 | 118 | 550 | 32,700 |
| December | 930 | ............ | 210 | 12,900 |
| The year | 2,510 | ............ | 464 | 338,000 |

NOTE.—See footnote to table of daily discharge.

### SWEETHEART FALLS CREEK NEAR SNETTISHAM.

Location.—In latitude 57° 56½′ N., longitude 133° 41′ W., on east shore 1 mile from head of south arm of Port Snettisham, 3 miles south of mouth of Whiting River, 7 miles by water from Snettisham, and 42 miles by water from Juneau. No large tributaries enter river between gaging station and outlet of large lake, 2½ miles upstream.

Drainage area.—27 square miles (measured on United States Geological Survey topographic map of the Juneau gold belt, edition of 1905).

Records available.—July 31, 1915, to March 31, 1917; May 21, 1918, to December 31, 1918.

Gage.—Stevens water-stage recorder on right bank, 300 feet upstream from tidewater on east shore of Port Snettisham. Gage washed out in November, 1917, and record from April 20, 1917, lost with gage. New Stevens water-stage recorder installed May 21, 1918, at same datum and at approximate location of old gage.

Discharge measurements.—At medium and high stages, made from cable across river one-fourth mile up stream from gage; at low stages, made by wading in channel at mouth of creek exposed at low tide.

Channel and control.—From the outlet of the lake at an elevation of 520 feet above sea level and 2½ miles from tidewater the water descends in a series of rapids and falls through a narrow, deep canyon. Gage is in a pool at foot of two falls, each 25 feet high, which are known as Sweetheart Falls; outlet of pool is a natural rock weir, which forms a well-defined and permanent control for gage.

Extremes of discharge.—1915–1918: Maximum stage recorded, 7.15 feet at midnight, September 26, 1918 (discharge, computed from an extension of the rating curve, 2,880 second-feet); minimum flow, estimated from discharge measurement and climatic data, 15 second-feet February 11, 1916.

Ice.—Stage-discharge relation not affected by ice.

Accuracy.—Stage-discharge relation permanent. Rating curve well defined between 40 and 1,300 second-feet; extended beyond these limits by estimation. Operation of water-stage recorder satisfactory except for period September 26–28, as shown in footnote to daily discharge table. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table gage heights for regular intervals of day. Results excellent except for period of break in record and for discharge above 1,300 second-feet, for which they are fair.

In the fall and winter the run-off is small because the precipitation is in the form of snow, and because of the small amount of ground storage; during a hot, dry period the low run-off from the ground and lake stage is augmented by melting ice from one glacier.

*Discharge measurements of Sweetheart Falls Creek near Snettisham during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. |
|---|---|---|
| | *Feet.* | *Sec.-ft.* |
| May 24 | 1.35 | 253 |
| Sept. 1 | 3.38 | 1,030 |

*Daily discharge, in second-feet, of Sweetheart Falls Creek near Snettisham for 1918.*

| Day. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|
| 1 | ........ | 565 | 645 | 545 | 992 | 446 | 765 | 625 |
| 2 | ........ | 488 | 545 | 463 | 665 | 348 | 545 | 585 |
| 3 | ........ | 456 | 491 | 410 | 470 | 382 | 379 | 435 |
| 4 | ........ | 459 | 452 | 393 | 368 | 565 | 282 | 324 |
| 5 | ........ | 525 | 446 | 365 | 306 | 725 | 380 | 249 |
| 6 | ........ | 645 | 488 | 382 | 264 | 545 | 1,140 | 210 |
| 7 | ........ | 745 | 625 | 446 | 234 | 418 | 1,220 | 191 |
| 8 | ........ | 685 | 725 | 452 | 216 | 407 | 785 | 178 |
| 9 | ........ | 785 | 805 | 404 | 199 | 372 | 505 | 157 |
| 10 | ........ | 865 | 805 | 358 | 288 | 315 | 344 | 148 |
| 11 | ........ | 990 | 805 | 330 | 463 | 288 | 261 | 135 |
| 12 | ........ | 968 | 785 | 306 | 400 | 368 | 216 | 117 |
| 13 | ........ | 885 | 705 | 300 | 315 | 449 | 219 | 103 |
| 14 | ........ | 845 | 685 | 309 | 258 | 463 | 188 | 95 |
| 15 | ........ | 905 | 705 | 309 | 228 | 428 | 171 | 88 |
| 16 | ........ | 885 | 725 | 410 | 222 | 344 | 150 | 104 |
| 17 | ........ | 865 | 765 | 525 | 285 | 300 | 137 | 119 |
| 18 | ........ | 845 | 805 | 463 | 730 | 365 | 121 | 133 |
| 19 | ........ | 865 | 785 | 446 | 945 | 400 | 108 | 133 |
| 20 | ........ | 765 | 725 | 905 | 785 | 390 | 104 | 117 |
| 21 | 267 | 705 | 653 | 905 | 525 | 348 | 181 | 111 |
| 22 | 258 | 645 | 585 | 905 | 376 | 291 | 418 | 135 |
| 23 | 246 | 645 | 545 | 1,190 | 306 | 234 | 438 | 146 |
| 24 | 252 | 705 | 525 | 1,260 | 330 | 213 | 460 | 176 |
| 25 | 282 | 925 | 488 | 1,140 | 622 | 191 | 410 | 183 |
| 26 | 327 | 865 | 463 | 885 | 1,790 | 178 | 354 | 216 |
| 27 | 396 | 805 | 442 | 805 | 2,470 | 176 | 321 | 205 |
| 28 | 705 | 765 | 505 | 1,040 | 1,710 | 205 | 273 | 171 |
| 29 | 1,120 | 745 | 505 | 1,240 | 1,120 | 297 | 333 | 144 |
| 30 | 1,010 | 745 | 488 | 1,440 | 685 | 410 | 585 | 127 |
| 31 | 745 | ........ | 585 | 1,305 | ........ | 780 | ........ | 111 |

NOTE.—Discharge Sept. 26–28 estimated, because inner well and float wires became disarranged during flood, by high-water mark in well (gage height 7.15 feet) and comparison with hydrographs of near-by stations.

*Monthly discharge of Sweetheart Falls Creek near Snettisham for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| May 21–31 | 1,120 | 246 | 510 | 11,100 |
| June | 990 | 456 | 753 | 44,800 |
| July | 805 | 442 | 623 | 38,300 |
| August | 1,440 | 300 | 666 | 41,000 |
| September | 2,470 | 199 | 619 | 36,800 |
| October | 780 | 176 | 376 | 23,100 |
| November | 1,220 | 104 | 393 | 23,400 |
| December | 625 | 88 | 193 | 11,900 |
| The period | .......... | .......... | .......... | 230,000 |

NOTE.—See footnote to table of daily discharge.

### CRATER LAKE OUTLET AT SPEEL RIVER, PORT SNETTISHAM.

LOCATION.—At outlet of Crater Lake, 1 mile upstream from edge of tide flats at head of north arm of Port Snettisham, 2 miles by trail from cabins of Speel River project, which are 42 miles by water from Juneau.

DRAINAGE AREA.—11.9 square miles above water-stage recorder at lake outlet, and 13 square miles above staff gage at beach (measured on topographic maps of the Alaska Boundary Tribunal, edition of 1895).

RECORDS AVAILABLE.—January 23, 1913, to December 31, 1918.

GAGE.—Stevens water-stage recorder on left shore of lake 100 feet upstream from outlet. A locally made water-stage recorder having a natural vertical scale and a time scale of 7 inches to 24 hours was used until replaced by Stevens gage June 29, 1916. The gage datum remained the same during the period. During the winter, because of inaccessible location and deep snow, the operation of the gage at the lake was discontinued, and the stage read at staff gage in channel exposed at low tide at beach. The first gage at beach was set at an unknown datum and washed out in winter of 1915–16. Another staff gage was set at about the same location November 24, 1916. Other staff gages were set at about the same location January 11 and November 13, 1918.

DISCHARGE MEASUREMENTS.—Made from cable across outlet of lake, 100 feet downstream from gage and 10 feet upstream from crest of first falls. The rope sling from which discharge measurements were first made was replaced in fall of 1915 by a standard U. S. Geological Survey gaging car, making more reliable measurements possible.

CHANNEL AND CONTROL.—The gage is on left shore of lake, 100 feet upstream from outlet, where the stream becomes constricted into a narrow channel, the bed of which is composed of large boulders and rock outcrops that form a well-defined and permanent control.

ACCURACY.—Stage-discharge relation permanent. Rating curve defined by 19 discharge measurements, 13 of which were made by employees of the Speel River Project (Inc.) and 6 by an engineer of the United States Geological Survey, and is well defined below and extended above 1,000 second-feet. Rating curve used January 1 to June 18 and November 18 to December 31 for staff gages at beach fairly well defined. Operation of water-stage recorder satisfactory except for September 10–14, when gage clock was run down, and 8 a. m. September 2–27, when record was badly torn by pencil during large flood. Discharge record January 1 to June 18 and November 18 to December 31 computed from gage-height records for staff gages at beach. Daily discharge June 20 to November 17 ascertained by applying to rating table daily gage height determined by inspecting gage-height graph, or for days of considerable fluctuation, by averaging results obtained by applying to rating table mean gage heights for regular intervals of the day.

Crater Lake is 1,010 feet above sea level and covers 1.1 square miles. The sides of the mountains surrounding the lake are steep and barren, and the tops are covered by glaciers.

*Discharge measurements of Crater Lake outlet at Speel River, Port Snettisham, during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| Jan. 25 | 1.72 | 40.0 | Mar. 29 | 1.25 | 9.4 |
| 30 | 1.62 | 26.3 | May 25 | 1.89 | 73 |

NOTE.—Gage heights refer to datum of staff gage at beach.

*Daily discharge, in second-feet, of Crater Lake outlet at Speel River, Port Snettisham, for 1918.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ....... | 24 | 12 | 10 | 34 | 155 | 338 | 517 | 562 | 231 | 251 | 206 |
| 2 | ....... | 23 | 13 | 10 | 43 | 129 | 282 | 416 | 402 | 216 | 164 | 132 |
| 3 | ....... | 23 | 14 | 10 | 48 | 140 | 265 | 375 | 316 | 398 | 108 | 127 |
| 4 | ....... | 24 | 14 | 11 | 53 | 155 | 251 | 350 | 280 | 562 | 76 | 91 |
| 5 | ....... | 24 | 15 | 10 | 60 | 438 | 261 | 316 | 255 | 517 | 92 | 88 |
| 6 | ....... | 25 | 15 | 10 | 67 | 195 | 338 | 362 | 235 | 327 | 662 | 86 |
| 7 | ....... | 26 | 14 | 10 | 65 | 255 | 457 | 443 | 216 | 241 | 568 | 74 |
| 8 | ....... | 25 | 14 | 11 | 63 | 270 | 517 | 402 | 200 | 293 | 251 | 62 |
| 9 | ....... | 24 | 15 | 12 | 68 | 336 | 532 | 350 | 362 | 227 | 139 | 55 |
| 10 | ....... | 23 | 15 | 12 | 72 | 525 | 532 | 316 | ....... | 178 | 92 | 44 |
| 11 | 17 | 21 | 15 | 12 | 83 | 358 | 532 | 304 | ....... | 148 | 67 | 48 |
| 12 | 17 | 20 | 14 | 11 | 94 | 409 | 517 | 282 | ....... | 223 | 58 | 44 |
| 13 | 17 | 16 | 14 | 11 | ....... | 400 | 472 | 316 | ....... | 350 | 58 | 41 |
| 14 | 17 | 12 | 14 | 11 | ....... | 380 | 487 | 350 | ....... | 304 | 52 | 38 |
| 15 | 17 | 12 | 15 | 12 | ....... | 409 | 517 | 362 | 186 | 245 | 47 | 41 |
| 16 | 17 | 12 | 14 | 12 | ....... | 496 | 547 | 517 | 225 | 161 | 41 | 44 |
| 17 | 15 | 11 | 13 | 13 | ....... | 554 | 594 | 547 | 350 | 135 | 39 | 51 |
| 18 | 16 | 11 | 14 | 14 | ....... | 496 | 642 | 429 | 742 | 194 | 44 | 91 |
| 19 | 17 | 10 | 14 | 80 | ....... | 450 | 626 | 547 | 728 | 194 | 35 | 58 |
| 20 | 17 | 10 | 13 | 53 | ....... | 350 | 578 | 578 | 443 | 146 | 45 | 48 |
| 21 | 17 | 10 | 12 | 46 | ....... | 327 | 542 | 815 | 261 | 116 | 55 | 38 |
| 22 | 44 | 10 | 11 | 36 | ....... | 304 | 487 | 762 | 176 | 95 | 175 | 48 |
| 23 | 77 | 10 | 10 | 32 | ....... | 316 | 472 | 1,130 | 153 | 78 | 118 | 55 |
| 24 | 60 | 10 | 10 | 29 | ....... | 362 | 457 | 1,230 | 208 | 68 | 113 | 62 |
| 25 | 39 | 10 | 10 | 27 | ....... | 517 | 472 | 780 | 313 | 62 | 108 | 70 |
| 26 | 38 | 11 | 10 | 24 | 77 | 472 | 457 | 578 | ....... | 60 | 104 | 66 |
| 27 | 36 | 11 | 10 | 23 | 106 | 402 | 457 | 594 | ....... | 58 | 100 | 62 |
| 28 | 32 | 11 | 10 | 23 | 610 | 375 | 626 | 868 | 745 | 58 | 91 | 48 |
| 29 | 29 | 11 | 10 | 23 | 900 | 388 | 594 | 1,110 | 416 | 66 | 104 | 44 |
| 30 | 26 | ....... | 10 | 24 | 325 | 402 | 487 | 1,450 | 278 | 95 | 122 | 36 |
| 31 | 25 | ....... | 11 | ....... | 255 | ....... | 610 | 920 | ....... | 227 | ....... | 29 |

NOTE.—Daily discharge, for days when staff gages were not read during periods Jan. 1 to June 19 and Nov. 18 to Dec. 31, estimated from climatic data and records of flow for Long River. Discharge estimated for following periods, because water-stage recorder was not operating: Sept. 10–14 (mean discharge, 335 second-feet) and Sept. 26–27 (mean discharge, 1,300 second-feet), by comparison with records of flow for Long River. Records Jan. 1 to June 19 and Nov. 18 to Dec. 31 show discharge at mouth of creek at beach; June 20 to Nov. 17, discharge at outlet of Crater Lake. Mean discharge estimated 44 second-feet Jan. 1–10 and 75 second-feet May 13–25.

*Monthly discharge of Crater Lake outlet at Speel River, Port Snettisham, for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | ............ | 15 | 33.2 | 2,040 |
| February | 26 | 10 | 16.8 | 933 |
| March | 15 | 10 | 12.7 | 781 |
| April | 80 | 10 | 20.7 | 1,230 |
| May | 900 | 34 | 129 | 7,930 |
| June | 554 | 129 | 347 | 20,600 |
| July | 642 | 251 | 482 | 29,600 |
| August | 1,450 | 282 | 591 | 36,300 |
| September | ............ | 186 | 411 | 24,500 |
| October | 562 | 58 | 202 | 12,400 |
| November | 662 | 35 | 133 | 7,910 |
| December | 206 | 29 | 65.4 | 4,020 |
| The year | ............ | 10 | 204 | 148,000 |

NOTE.—See footnote to table of daily discharge.

### LONG RIVER BELOW SECOND LAKE, AT PORT SNETTISHAM.

Location.—One-half mile downstream from outlet of Second Lake, 1 mile downstream from outlet of Long Lake, one-half mile upstream from head of Indian Lake; 2½ miles by trail and boat across Second Lake from cabins of the Speel River project at head of the North Arm of Port Snettisham, 42 miles by water from Juneau.

Drainage area.—33.2 square miles (measured on sheet No. 12 of the Alaska Boundary Tribunal maps, edition of 1895).

Records available.—November 11, 1915, to December 31, 1918.

Gage.—Stevens continuous water-stage recorder on right bank one-half mile below outlet of Second Lake.

Discharge measurements.—At medium and high stages made from cable across river at gage; at low stages made by wading one-fourth mile downstream.

Channel and control.—At the gage the channel is deep and the current sluggish; banks are low and are overflowed at extremely high stages; bed smooth except for one large boulder. A rapid, 500 feet downstream, forms a well-defined and permanent control.

Extremes of discharge.—Maximum stage during year, 10.2 feet at about 1 a. m. September 27 (discharge, estimated from extension of rating curve, 5,300 second-feet); minimum flow, 24 second-feet, March 28.

1916–1918: Maximum stage, 10.2 feet September 27, 1918 (discharge, estimated from extension of rating curve, 5,300 second-feet); minimum flow, 23 second-feet, February 13, 1916.

Ice.—Stage-discharge relation affected by ice during January, February, March, and April.

Accuracy.—Stage-discharge relation permanent; affected by ice or poor connection between well and river January 1–17 and January 28 to April 25. Rating curve fairly well defined between 50 and 400 second-feet and well defined between 400 and 2,000 second-feet. Operation of water-stage recorder satisfactory except for periods indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to the rating table daily gage heights determined by inspecting the gage-height graph. Records good except for stages below 400 second-feet and periods of break in record, for which they are fair.

The area draining to Long River between Long Lake Outlet and this station comprises only 1.3 square miles, including First Lake and Second Lake. Because this area is at a low altitude and has no glaciers the run-off per square mile from it is greater early in the spring but much less in summer than that from the area above Long Lake, which is partly covered by glaciers.

*Discharge measurements of Long River below Second Lake, at Port Snettisham, during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. |
|---|---|---|
| | *Feet.* | *Sec.-ft.* |
| Mar. 28 | a 0.70 | 24 |
| May 25 | 1.94 | 224 |

a Stage-discharge relation affected by ice.

*Daily discharge, in second-feet, of Long River below Second Lake, at Port Snettisham, for 1918.*

| Day. | Jan. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100 | ........ | 175 | 530 | 780 | 1,180 | 1,340 | 680 | 530 | 474 |
| 2 | 225 | ........ | 186 | 450 | 680 | 1,020 | 1,020 | 600 | 393 | 456 |
| 3 | 200 | ........ | 225 | 411 | 640 | 930 | 840 | 862 | 282 | 354 |
| 4 | 150 | ........ | 227 | 405 | 600 | 840 | 740 | 1,260 | 207 | 264 |
| 5 | 116 | ........ | 237 | 450 | 600 | 780 | 660 | 820 | 457 | 200 |
| 6 | 96 | ........ | 244 | 530 | 720 | 840 | 600 | 975 | 1,440 | 175 |
| 7 | 88 | ........ | 204 | 620 | 885 | 975 | 565 | 760 | 1,090 | 154 |
| 8 | 82 | ........ | 184 | 680 | 1,060 | 1,410 | 530 | 780 | 700 | 138 |
| 9 | 76 | ........ | 213 | 720 | 1,160 | 800 | 512 | 600 | 456 | 130 |
| 10 | 73 | ........ | 234 | 780 | 1,160 | 740 | 769 | 480 | 314 | 126 |
| 11 | 70 | ........ | 254 | 862 | 1,160 | 720 | 1,180 | 418 | 244 | 120 |
| 12 | 69 | ........ | 295 | 840 | 1,140 | 660 | 952 | 530 | 215 | 119 |
| 13 | 68 | ........ | 301 | 780 | 1,090 | 720 | 720 | 740 | 198 | 118 |
| 14 | 67 | ........ | 312 | 800 | 1,110 | 780 | 565 | 760 | 168 | 118 |
| 15 | 66 | ........ | 285 | 840 | 1,180 | 820 | 509 | 600 | 152 | 117 |
| 16 | 64 | 32 | 259 | 840 | 1,210 | 680 | 565 | 435 | 135 | 117 |
| 17 | 63 | 35 | 230 | 840 | 1,280 | 1,140 | 866 | 396 | 132 | 117 |
| 18 | 62 | 38 | 220 | 908 | 1,380 | 952 | 1,690 | 512 | 120 | 157 |
| 19 | 61 | 220 | 212 | 885 | 1,360 | 1,060 | 1,690 | 418 | 108 | 162 |
| 20 | 61 | 140 | 205 | 840 | 1,280 | 1,160 | 1,160 | 366 | 103 | 132 |
| 21 | 59 | 120 | 198 | 582 | 1,240 | 1,440 | 780 | 293 | 137 | 118 |
| 22 | 131 | 100 | 196 | 760 | 1,140 | 1,480 | 548 | 232 | 285 | 209 |
| 23 | 194 | 90 | 200 | 760 | 1,060 | 2,110 | 480 | 180 | 262 | 222 |
| 24 | 154 | 84 | 210 | 820 | 1,060 | 2,110 | 520 | 181 | 339 | 246 |
| 25 | 120 | 116 | 225 | 998 | 1,060 | 1,510 | 844 | 162 | 309 | 175 |
| 26 | 103 | 127 | 259 | 975 | 1,020 | 1,870 | 2,940 | 144 | 298 | 237 |
| 27 | 95 | 141 | 295 | 885 | 998 | 1,260 | 4,130 | 134 | 259 | 184 |
| 28 | 84 | 144 | 600 | 820 | 1,240 | 1,570 | 2,110 | 137 | 227 | 141 |
| 29 | 80 | 166 | 930 | 840 | 1,260 | 1,840 | 1,180 | 277 | 317 | 120 |
| 30 | 75 | 175 | 820 | 862 | 1,160 | 2,480 | 840 | 323 | 399 | 114 |
| 31 | 70 | ........ | 660 | ........ | 1,310 | 1,900 | ........ | 548 | ........ | 108 |

NOTE.—Discharge estimated for following periods, because stage-discharge relation was affected by ice or poor connection between well and river or because of unsatisfactory operation of water-stage recorder: Jan. 1-17, Jan. 28-31, Feb. 1-28 (mean discharge, 41 second-feet), Mar. 1-31 (mean discharge, 26 second-feet), Apr. 1-15 (mean discharge, 27 second-feet), and Apr. 16-25, by comparison with hydrographs for Crater and Carlson creeks and climatic data for Juneau; May 1-24, September 27-29, and Dec. 29 and 31, by maximum and minimum stages indicated by recorder and comparison with hydrographs of other stations.

*Monthly discharge of Long River below Second Lake, at Port Snettisham, for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 225 | 59 | 97.5 | 6,000 |
| February | ............ | ............ | 41 | 2,280 |
| March | ............ | ............ | 26 | 1,600 |
| April | ............ | ............ | 71.1 | 4,230 |
| May | 930 | 175 | 300 | 18,400 |
| June | 998 | 405 | 744 | 44,300 |
| July | 1,380 | 600 | 1,070 | 65,800 |
| August | 2,480 | 660 | 1,220 | 75,000 |
| September | 4,130 | 509 | 1,060 | 63,100 |
| October | 1,260 | 134 | 504 | 31,000 |
| November | 1,440 | 103 | 342 | 20,400 |
| December | 474 | 108 | 181 | 11,100 |
| The year | 4,130 | ............ | 471 | 343,000 |

NOTE.—See footnote to table of daily discharge.

## SPEEL RIVER AT PORT SNETTISHAM.

LOCATION.—At entrance of canyon one-fourth mile downstream from mouth of Long River and 8 miles upstream from tide flats and the cabins of Speel River Project, Inc., which are at head of north arm of Port Snettisham, and 42 miles by water from Juneau.

Drainage area.—Not measured.

Records available.—July 1, 1916, to September 30, 1918.

Gage.—Stevens water-stage recorder, 150 feet to the left of the constriction of the river at the entrance of the canyon. The gage is reached from cabins of the Speel River Project by trail to head of Second Lake, boat across Second Lake, trail to head of Indian Lake, boat across Indian Lake, trail down Long River and Indian River to canyon, and cable across river near entrance of the canyon—a total distance of about 7 miles. Recorder washed out during flood September 26-27, 1918.

Discharge measurements.—Made from cable having a clear span of 400 feet across river, half a mile below gage and one-fourth mile below lower end of canyon.

Channel and control.—For several miles above the canyon the river flows through a wide, flat sandy bed in which the channels are continually shifting. The river is constricted from a width of 500 feet to 75 feet at the entrance of the canyon. This constriction of the channel and a rock outcrop at the entrance of the canyon form a very sensitive and permanent control. The extreme range in stage is 28 feet. Above a stage of 22 feet part of the flow passes through a secondary channel, the bed of which is rock overgrown with brush, which begins near gage and reenters main channel at lower end of canyon. Below a stage of about 4 feet water from stream does not reach well except by seepage through the gravel. Stage-discharge relation is therefore not permanent for stages below 4 feet. At the gaging cable the bed of the river is gravel, with one large rock outcrop near the middle of the stream. The current is very swift, and the stream carries a large quantity of sand in suspension.

Extremes of discharge.—1916-1918: Maximum discharge, estimated by multiplying maximum discharge at Long River September 27, 1918, by 6. 8 (the ratio between the maximum discharges at Speel and Long rivers August 30, 1918), 35,600 second-feet, September 27, 1918; minimum discharge, 127 second-feet, March 28-31, 1918.

Ice.—Ice does not form at control, but so much frost forms in gage shelter and on metal parts of gage that the gage does not operate satisfactorily during the winter.

Accuracy.—Stage-discharge relation permanent except for stages below about 1,000 second-feet, when frequent measurements are necessary to estimate the flow. Rating curve fairly well defined between 1,200 and 10,000 second-feet; extended above 10,000 second-feet; rating curve used January 28 to March 31 determined by two discharge measurements, fairly well defined. Operation of water-stage recorder not satisfactory for periods indicated in footnote to daily-discharge table because of the frequent stopping of clock. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph. Results fair for periods when gage was operating satisfactorily; poor for periods when clock was not running.

*Discharge measurements of Speel River at Port Snettisham during the year ending Sept. 30, 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. |
|---|---|---|
| | *Feet.* | *Sec.-ft.* |
| Jan. 28 | a 4.2 | 243 |
| Mar. 28 | a 2.7 | 127 |
| Sept. 3 | 13.6 | 5,250 |

a Stage-discharge relation affected by ice.

*Daily discharge, in second-feet, of Speel River at Port Snettisham for 1918.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | ........ | 206 | 173 | ........ | 690 | ........ | ........ | 6,800 | 8,500 |
| 2 | ........ | 190 | 166 | ........ | 715 | ........ | ........ | 6,150 | 6,690 |
| 3 | ........ | 182 | 166 | ........ | 740 | ........ | ........ | 5,750 | 4,980 |
| 4 | ........ | 182 | 166 | ........ | 830 | ........ | ........ | 5,220 | ........ |
| 5 | ........ | 173 | 166 | ........ | 860 | ........ | ........ | 4,370 | ........ |
| 6 | ........ | 173 | 152 | ........ | 890 | ........ | ........ | 4,490 | ........ |
| 7 | ........ | 173 | 145 | ........ | 980 | ........ | ........ | 4,900 | ........ |
| 8 | ........ | 166 | 138 | ........ | 980 | ........ | ........ | 4,190 | ........ |
| 9 | ........ | 166 | 138 | ........ | 1,040 | ........ | ........ | 3,950 | ........ |
| 10 | ........ | 166 | 138 | ........ | 1,070 | ........ | ........ | 4,070 | ........ |
| 11 | ........ | 166 | 138 | ........ | 1,130 | ........ | ........ | 4,010 | ........ |
| 12 | ........ | 166 | 138 | ........ | 1,160 | ........ | ........ | 3,890 | ........ |
| 13 | ........ | 166 | 133 | ........ | 1,220 | ........ | ........ | 4,130 | ........ |
| 14 | ........ | 158 | 133 | ........ | 1,280 | ........ | ........ | 4,370 | ........ |
| 15 | ........ | 158 | 133 | ........ | 1,280 | ........ | ........ | 4,760 | ........ |
| 16 | ........ | 158 | 130 | ........ | 1,320 | ........ | ........ | 6,580 | ........ |
| 17 | ........ | 158 | ........ | ........ | 1,350 | ........ | ........ | 5,950 | ........ |
| 18 | ........ | 166 | ........ | ........ | 1,350 | ........ | ........ | 5,390 | ........ |
| 19 | ........ | 166 | ........ | 1,000 | 1,420 | 4,830 | ........ | 5,950 | ........ |
| 20 | ........ | 152 | ........ | 600 | 1,490 | 4,250 | 8,610 | 7,280 | ........ |
| 21 | ........ | 173 | ........ | 620 | 1,560 | ........ | 7,400 | 9,200 | ........ |
| 22 | ........ | 182 | ........ | 640 | 1,740 | ........ | 6,800 | 9,820 | ........ |
| 23 | ........ | 182 | ........ | 640 | 1,805 | ........ | 6,800 | 20,000 | ........ |
| 24 | ........ | 190 | ........ | 665 | 1,840 | ........ | 5,850 | ........ | ........ |
| 25 | ........ | 190 | ........ | 665 | 1,910 | ........ | 6,580 | ........ | ........ |
| 26 | ........ | 190 | ........ | 665 | 1,940 | ........ | 6,470 | ........ | ........ |
| 27 | ........ | 198 | ........ | 665 | 2,190 | ........ | 6,150 | ........ | ........ |
| 28 | 243 | 198 | 127 | 665 | 4,130 | ........ | 6,580 | ........ | ........ |
| 29 | 233 | 173 | 127 | 690 | 4,130 | ........ | 6,800 | ........ | ........ |
| 30 | 215 | ........ | 127 | 690 | 3,130 | ........ | 6,920 | ........ | ........ |
| 31 | 215 | ........ | 127 | ........ | 2,500 | ........ | 7,660 | ........ | ........ |

NOTE.—Discharge estimated for following periods, because of unsatisfactory operation of water-stage recorder, by comparison with records of flow for Long River: Jan. 1-27, 400 second-feet; March 17-27, 130 second-feet; Apr. 1-10, 130 second-feet; Apr. 11-18, 150 second-feet; Apr. 19; May 31; June 1-18, 3,600 second-feet; June 21-30, 4,500 second-feet; July 1-19, 5,900 second-feet; Aug. 23; Aug. 24-31, 11,100 second-feet; Sept. 1; Sept. 4-30, 7,200 second-feet.

*Monthly discharge of Speel River at Port Snettisham for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | ............ | ............ | 378 | 23,200 |
| February | 206 | 166 | 181 | 10,100 |
| March | 173 | 127 | 141 | 8,670 |
| April | 1,000 | 600 | 357 | 21,200 |
| May | 4,130 | 690 | 1,570 | 96,500 |
| June | ............ | ............ | 3,960 | 236,000 |
| July | ............ | ............ | 6,300 | 387,000 |
| August | ............ | 3,890 | 7,400 | 455,000 |
| September | ............ | ............ | 7,150 | 425,000 |
| The period | ............ | ............ | ............ | 1,660,000 |

NOTE.—See footnote to table of daily discharge.

### GRINDSTONE CREEK AT TAKU INLET.

LOCATION.—On north shore of Taku Inlet, between Point Bishop and Point Salisbury, one-fourth mile west of mouth of Rhine Creek and 11 miles by water from Juneau.

DRAINAGE AREA.—Not measured.

RECORDS AVAILABLE.—May 6, 1916, to December 31, 1917.

GAGE.—Stevens continuous water-stage recorder on left bank, 200 feet from tidewater, installed September 16, 1916. A Lietz seven-day graph water-stage recorder was used May 6 to June 17, 1916.

DISCHARGE MEASUREMENTS.—At all stages made by wading either in the channel on the beach, which is exposed at low tide, or 100 feet below gage at high tide.

CHANNEL AND CONTROL.—For a distance of one-fourth mile from tidewater the stream descends in a series of rapids and falls through a narrow, rocky channel. The gage is at upper end of a turbulent pool between two falls, the lower of which forms a well-defined control. When gage was installed, logs were jammed in channel near upper end of pool.

EXTREMES OF DISCHARGE.—1916–18: Maximum stage, 6 feet at 7 p. m. September 26, 1918 (discharge, estimated from an extension of the rating curve, 700 second-feet); minimum stage, —0.24 foot April 5–7, 1918 (discharge, 2.6 second-feet).

ICE.—Stage-discharge relation sometimes affected by ice.

ACCURACY.—Stage-discharge relation permanent. Rating curve well defined below 150 second-feet; extended above 150 second-feet by estimation. Operation of water-stage recorder satisfactory except for periods shown in the footnote to daily-discharge table. Discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table mean gage heights for regular intervals of day. Records good except those for periods of break in record and discharge above 150 second-feet, which are poor.

*Discharge measurements of Grindstone Creek at Taku Inlet during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. |
|---|---|---|
| | *Feet.* | *Sec.-ft.* |
| Jan. 9 | 0.30 | 11 |
| Mar. 27 | —.22 | 2.9 |

*Daily discharge, in second-feet, of Grindstone Creek at Taku Inlet for 1918.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 8.4 | 4.3 | 2.7 | 12 | 52 | 51 | 34 | 88 | ........ | 68 |
| 2 | 20 | 8.4 | 4.2 | 2.7 | 12 | 47 | 46 | 34 | 71 | ........ | 50 |
| 3 | 18 | 8.4 | 3.4 | 2.7 | 15 | 47 | 39 | 35 | 60 | ........ | 39 |
| 4 | 19 | 8.1 | 3.1 | 2.7 | 20 | 51 | 36 | 35 | 53 | ........ | 31 |
| 5 | 18 | 7.9 | 3.1 | 2.6 | 23 | 62 | 36 | 36 | 47 | ........ | 27 |
| 6 | 16 | 7.9 | 3.2 | 2.6 | 27 | 87 | 47 | 36 | 40 | ........ | 27 |
| 7 | 14 | 7.3 | 3.3 | 2.6 | 28 | 86 | 48 | 37 | 35 | ........ | 25 |
| 8 | 12 | 7.3 | 2.9 | 3.2 | 26 | 76 | 45 | 37 | 31 | ........ | 23 |
| 9 | 11 | 7.7 | 2.9 | 6.9 | 27 | 75 | 43 | 37 | 28 | ........ | 22 |
| 10 | 12 | 7.1 | 2.9 | 4.9 | 35 | 73 | 40 | 37 | 50 | ........ | 21 |
| 11 | 11 | 6.9 | 2.9 | 4.2 | 40 | 69 | 38 | 38 | 35 | 26 | 20 |
| 12 | 11 | 6.9 | 2.9 | 4.0 | 43 | 67 | 43 | 37 | 29 | 26 | 19 |
| 13 | 9.4 | 6.6 | 2.9 | 4.2 | 42 | 65 | 42 | 38 | 26 | 25 | ........ |
| 14 | 9.0 | 6.0 | 3.2 | 4.3 | 42 | 76 | 41 | 38 | 31 | 23 | ........ |
| 15 | 8.8 | 4.8 | 3.2 | 4.3 | 40 | 75 | 41 | 38 | 24 | 23 | ........ |
| 16 | 9.2 | 4.9 | 3.2 | 4.3 | 38 | 68 | 38 | 39 | 24 | 22 | ........ |
| 17 | 8.4 | 5.1 | 3.2 | 4.3 | 37 | 63 | 37 | 40 | 29 | 21 | ........ |
| 18 | 8.2 | 5.1 | 3.2 | 11 | 36 | 62 | 36 | 39 | 46 | 19 | ........ |
| 19 | 8.1 | 5.4 | 3.2 | 21 | 37 | 63 | 35 | 40 | 31 | 19 | ........ |
| 20 | 7.7 | 5.2 | 3.0 | 15 | 36 | 53 | 34 | 41 | 27 | 21 | ........ |
| 21 | 9.8 | 5.2 | 2.7 | 11 | 36 | 53 | 33 | 42 | 24 | 39 | ........ |
| 22 | 16 | 5.4 | 2.7 | 10 | 36 | 49 | 31 | 46 | 23 | 55 | ........ |
| 23 | 16 | 5.1 | 2.7 | 11 | 36 | 47 | 30 | 112 | 88 | 46 | ........ |
| 24 | 16 | 4.8 | 2.8 | 12 | 36 | 49 | 29 | 93 | 31 | 38 | ........ |
| 25 | 14 | 4.8 | 2.8 | 11 | 37 | 90 | 28 | 83 | 92 | 31 | ........ |
| 26 | 12 | 4.8 | 2.8 | 9.8 | 36 | 72 | 27 | 90 | 365 | 27 | 33 |
| 27 | 11 | 4.8 | 2.8 | 9.8 | 39 | 73 | 27 | 103 | 310 | 27 | 22 |
| 28 | 10 | 4.4 | 2.7 | 9.8 | 90 | 58 | 27 | 124 | 134 | 31 | 19 |
| 29 | 9.8 | ........ | 2.7 | 10 | 95 | 66 | 28 | 257 | 96 | 85 | 17 |
| 30 | 9.4 | ........ | 2.9 | 11 | 75 | 73 | 27 | 314 | 75 | 65 | 17 |
| 31 | 9.0 | ........ | 2.9 | ........ | 60 | ........ | 32 | 121 | ........ | ........ | 17 |

NOTE.—Discharge estimated for following periods because of unsatisfactory operation of water-stage recorder: Jan. 1–6, from line drawn on cylinder; Jan. 7–8 and Feb. 26, by interpolation; Aug. 29–30 and Sept. 26–29, by gage-height graph drawn by comparison with that for Sheep Creek through maximum and stages indicated by recording pencil; Oct. 1–31 (mean discharge, 55 second-feet), Nov. 1–10 (mean discharge, 50 second-feet), and Dec. 13–25 (mean discharge, 21 second-feet), by comparison with records of flow for Crater Lake outlet at Port Snettisham and from maximum and minimum stages indicated by recording pencil Oct. 1 to Nov. 10.

*Monthly discharge of Grindstone Creek, at Taku Inlet for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 20 | 7.7 | 12.2 | 750 |
| February | 8.4 | 4.4 | 6.24 | 347 |
| March | 4.3 | 2.7 | 3.05 | 188 |
| April | 21 | 2.6 | 7.19 | 428 |
| May | 95 | 12 | 38.5 | 2,370 |
| June | 90 | 47 | 64.9 | 3,860 |
| July | 51 | 27 | 36.6 | 2,250 |
| August | 314 | 34 | 68.8 | 4,230 |
| September | 365 | 23 | 68.1 | 4,050 |
| October | ........ | ........ | 55.0 | 3,380 |
| November | ........ | 19 | 39.0 | 2,320 |
| December | 68 | 17 | 24.8 | 1,530 |
| The year | 365 | 2.6 | 35.4 | 25,700 |

NOTE.—See footnote to table of daily discharge.

### CARLSON CREEK AT SUNNY COVE.

Location.—At Sunny Cove, on west shore of Taku Inlet, 20 miles by water from Juneau.

Drainage area.—22.26 square miles (determined by engineering department of Alaska Gastineau Mining Co. from surveys made by that company).

Records available.—July 18, 1916, to December 31, 1918.

Gage.—Stevens water-stage recorder on left bank, 2 miles from tidewater; inspected several times a week by employees of Alaska Gastineau Mining Co.

Discharge measurements.—At high stages, made from cable across river one-half mile downstream from gage; at medium and low stages, made by wading 500 feet upstream from gage.

Channel and control.—Above the gage the stream meanders in one main channel and several small channels through a flat, sandy basin about a mile long; just below the gage the channel contracts and the stream passes over rocky falls that form a well-defined and permanent control. The point of zero flow is at gage height −1.5 feet.

Extremes of discharge.—1916–1918: Maximum stage, 8.1 feet at 2 p. m. September 26, 1918 (discharge, computed from extension of rating curve, 6,200 second-feet); minimum flow, estimated from climatic data and hydrographs for streams in near-by drainage basins, 10 second-feet, April 1–7, 1918.

Ice.—Stage-discharge relation affected by ice January 1 to May 3.

Accuracy.—Stage-discharge relation permanent. Rating curve well defined between 70 and 2,000 second-feet, extended below 70 second-feet to point of zero flow and above 2,000 second-feet by estimation; curve used January 1–25 determined by one discharge measurement, and form of standard rating curve fairly well defined. Operation of water-stage recorder satisfactory except for periods of break in record as indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging results obtained by applying to rating table mean gage heights for regular intervals of the day. Records good except for stages below 70 second-feet and above 2,000 second-feet, for period January 1 to May 3, when stage-discharge relation was affected by ice, and for periods of break in record, for which they are fair.

*Discharge measurements of Carlson Creek at Sunny Cove during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| Jan. 3 [a] | 0.52 | 112 | July 26 | 1.63 | 437 |
| Feb. 4 [a] | .25 | 23 | Aug. 23 | 4.10 | 1,610 |
| Mar. 27 [a] | | 10.3 | Sept. 21 | .66 | 199 |

[a] Control and river covered with thick ice; measurement made 2 miles below gage; metered discharge corrected by −5 per cent to give flow at gage.

*Daily discharge, in second-feet, of Carlson Creek at Sunny Cove for 1918.*

| Day. | Jan. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. |
|---|---|---|---|---|---|---|---|---|
| 1 | 67 | ........ | 86 | 405 | 745 | 530 | 470 | 227 |
| 2 | 175 | ........ | 90 | 524 | 575 | 455 | 382 | 219 |
| 3 | 125 | ........ | 125 | 416 | 575 | 455 | 320 | 845 |
| 4 | 97 | ........ | 152 | 470 | 575 | 425 | 290 | 1,110 |
| 5 | 80 | ........ | 152 | 575 | 622 | 560 | 265 | 574 |
| 6 | 75 | ........ | 180 | 816 | 840 | 515 | 233 | 320 |
| 7 | 72 | ........ | 152 | 860 | 975 | 710 | 233 | 290 |
| 8 | 70 | ........ | 154 | 820 | 950 | 470 | 223 | 485 |
| 9 | 68 | ........ | 177 | 820 | 928 | 440 | 202 | 308 |
| 10 | 67 | ........ | 221 | 820 | 860 | 402 | 1,150 | 278 |
| 11 | 67 | ........ | 263 | 860 | 905 | 393 | 590 | 259 |
| 12 | 66 | ........ | 292 | 860 | 882 | 345 | 302 | 818 |
| 13 | 66 | ........ | 290 | 745 | 905 | 620 | 247 | 861 |
| 14 | 66 | ........ | 285 | 905 | 1,000 | 455 | 233 | 622 |
| 15 | 64 | ........ | 221 | 882 | 928 | 504 | 253 | 440 |
| 16 | 62 | ........ | 210 | 860 | 882 | 636 | 440 | 272 |
| 17 | 60 | ........ | 190 | 860 | 950 | 440 | 1,000 | 312 |
| 18 | 57 | 90 | 191 | 860 | 882 | 666 | 1,520 | 410 |
| 19 | 57 | 180 | 174 | 860 | 780 | 867 | 530 | 340 |
| 20 | 57 | 105 | 167 | 710 | 710 | 1,000 | 338 | ........ |
| 21 | 60 | ........ | 148 | 675 | 675 | 974 | 229 | ........ |
| 22 | 62 | ........ | 156 | 605 | 605 | 1,050 | 185 | ........ |
| 23 | 63 | ........ | 172 | 692 | 575 | 1,760 | 430 | ........ |
| 24 | 67 | ........ | 191 | 820 | 530 | 1,200 | 343 | ........ |
| 25 | 67 | ........ | 237 | 1,340 | 485 | 698 | 1,540 | ........ |
| 26 | 58 | ........ | 320 | 840 | 470 | 710 | 4,110 | ........ |
| 27 | 46 | ........ | 302 | 840 | 788 | 995 | 1,930 | ........ |
| 28 | 38 | ........ | 1,050 | 762 | 1,000 | 975 | 470 | ........ |
| 29 | 32 | ........ | 1,250 | 928 | 590 | 1,300 | 315 | ........ |
| 30 | 29 | ........ | 668 | 928 | 564 | 1,670 | 245 | ........ |
| 31 | 27 | ........ | 491 | ........ | 870 | 692 | ........ | ........ |

NOTE.—Discharge estimated for following periods, because stage-discharge relation was affected by ice or water-stage recorder was not operating: Jan. 11–14, Jan. 26–31, Feb. 1–28 (mean discharge, 18 second-feet), Mar. 1–31 (mean discharge, 11 second-feet), Apr. 1–17 (mean discharge, 13 second-feet), Apr. 19, Apr. 21–30 (mean discharge, 76 second-feet), and May 1–3, by comparison with hydrograph for Grindstone Creek and climatic data at Juneau and from current-meter measurements; July 11–26, Aug. 29–Sept. 2, Sept. 11–17, and Sept. 19–20, from estimated gage-height graph drawn by comparison with that for Gold Creek through maximum and minimum stages indicated by recorder; Oct. 20–31 (mean discharge, 180 second-feet), Nov. 1–30 (mean discharge, 270 second-feet), and Dec. 1–31 (mean discharge, 125 second-feet), by comparison with records of flow for Long River.

*Monthly discharge of Carlson Creek at Sunny Cove for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 175 | 27 | 66.6 | 4,100 |
| February | ........ | ........ | 18.0 | 1,000 |
| March | ........ | ........ | 11.0 | 676 |
| April | ........ | ........ | 45.2 | 2,690 |
| May | 1,250 | 86 | 282 | 17,300 |
| June | 1,340 | 405 | 779 | 46,400 |
| July | 1,000 | 485 | 762 | 46,900 |
| August | 1,670 | 345 | 739 | 45,400 |
| September | 4,110 | 185 | 634 | 37,700 |
| October | ........ | ........ | 360 | 22,100 |
| November | ........ | ........ | 270 | 16,100 |
| December | ........ | ........ | 125 | 7,690 |
| The year | 4,110 | ........ | 341 | 248,000 |

NOTE.—See footnote to table of daily discharge.

## SHEEP CREEK NEAR THANE.

LOCATION.—At lower end of flat basin, above diversion dam for flume leading to Treadwell power house at beach and 1 mile by tramway and ore railway from Thane.

DRAINAGE AREA.—4.57 square miles above gaging bridge (measured on United States Geological Survey map of Juneau and vicinity, edition of 1917).

RECORDS AVAILABLE.—July 26, 1916, to December 31, 1918.

GAGE.—Stevens water-stage recorder on right bank, at pool formed by an artificial control just below small island three-tenths mile upstream from diversion dam. Recorder inspected once a week by an employee of the Alaska Castineau Mining Co.

DISCHARGE MEASUREMENTS.—At extremely high stages, made from gaging bridge two-tenths mile downstream from gage; at low stages, made by wading near bridge section. No streams enter between gage and measuring section, but seepage inflow ranges from a small amount to 10 per cent of total flow, the percentage of inflow usually being large after periods of heavy precipitation.

CHANNEL AND CONTROL.—The station is near the lower end of a flat basin through which the stream meanders in a channel having low banks and a bed of sand and gravel. An artificial control was built 2 feet below the intake for the gage well, to confine the flow in one channel during high water and to insure a permanent stage-discharge relation. The spillway of the control at low stages consists of a timber, 16 feet long, set in the bed of the stream. During medium and high stages another timber, 8 feet long, bolted at the top near the right end, forms part of the control. A 3-foot cut-off wall is driven at the upstream face of the spillway. There are wing walls at each end, and an 8-foot apron extends downstream from the control.

ICE.—Control covered with ice and snow from February 16 to April 20. Flow passes through gravel bed under and around weir and enters creek again above gaging section one-fourth mile downstream.

EXTREMES OF DISCHARGE.—Maximum stage during year, 3.5 feet, at 2 p. m. September 26 (discharge, estimated from extension of rating curve, 820 second-feet); minimum flow, estimated from climatic records and discharge measurement on March 29, 3.5 second-feet, March 29–31.

1916–1918: Maximum stage during period, 3.5 feet, at 2 p. m. September 26, 1918 (discharge, estimated from extension of rating curve, 820 second-feet); minimum flow, 1.0 second-foot, April 6–8, 1917.

ACCURACY.—Stage-discharge relation changed, owing to clogging with sand of intake pipe, May 29. Rating curve used January 1 to May 28 fairly well defined below 250 second-feet; curve used May 29 to December 31, fairly well defined below 700 second-feet. Operation of water-stage recorder satisfactory except for periods indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuation, by averaging discharges obtained by applying to rating table mean gage heights for regular intervals of the day. Records fair.

*Discharge measurements of Sheep Creek near Thane during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| Jan. 18 | 0.38 | 9.5 | Aug. 28 | 1.31 | 147 |
| Feb. 11 | .23 | 6.7 | Sept. 26 | 2.70 | 550 |
| 25 | [a]—.15 | 5.6 | 30 | .96 | 71 |
| Mar. 29 | ([b]) | 3.5 | Dec. 24 | .72 | 26 |
| July 23 | [c].90 | 54 | | | |

[a] Weir under 2 feet of ice and snow, water seeping through gravel and around weir entering creek above measuring section.
[b] Measurement made at tailrace of power house at beach.
[c] Intake pipe clogged with sand.

*Daily discharge, in second-feet, of Sheep Creek near Thane for 1918.*

| Day. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 11 | 9.5 | 5.1 | ...... | 9.5 | 83 | ...... | 55 | 154 | 59 | 77 | ...... |
| 2 | 11 | 9.2 | 5.0 | ...... | 9.5 | 75 | ...... | 48 | 104 | 53 | 64 | ...... |
| 3 | 12 | 9.0 | 5.0 | ...... | 9.9 | 75 | ...... | 47 | 70 | 86 | 51 | ...... |
| 4 | 13 | 8.7 | 4.9 | ...... | 19 | 86 | ...... | 46 | 60 | 116 | 46 | ...... |
| 5 | 14 | 8.4 | 4.8 | ...... | 43 | 97 | ...... | 44 | 53 | 79 | 140 | ...... |
| 6 | 14 | 8.3 | 4.7 | ...... | 43 | 126 | ...... | 42 | 46 | 64 | 220 | ...... |
| 7 | 13 | 7.9 | 4.6 | ...... | 43 | 126 | ...... | 42 | 44 | 64 | 104 | ...... |
| 8 | 11 | 7.6 | 4.6 | ...... | 41 | 121 | ...... | 42 | 38 | 62 | 86 | ...... |
| 9 | 11 | 7.6 | 4.5 | ...... | 55 | 126 | ...... | 42 | 33 | 53 | ...... | ...... |
| 10 | 10 | 7.5 | 4.5 | ...... | 70 | 116 | ...... | 41 | 86 | 55 | ...... | ...... |
| 11 | 10 | 7.3 | 4.4 | ...... | 78 | 116 | ...... | 41 | 49 | 51 | ...... | ...... |
| 12 | 10 | 7.1 | 4.4 | ...... | 85 | 108 | ...... | 41 | 40 | 90 | ...... | ...... |
| 13 | 10 | 7.0 | 4.3 | ...... | 66 | 102 | ...... | 62 | 33 | 86 | ...... | ...... |
| 14 | 10 | 6.9 | 4.3 | ...... | 64 | 116 | ...... | 49 | 31 | 100 | ...... | ...... |
| 15 | 10 | 6.7 | 4.2 | ...... | 55 | 116 | ...... | 49 | 33 | 77 | ...... | ...... |
| 16 | 9 | 6.5 | 4.2 | ...... | 57 | 108 | ...... | 57 | 35 | 68 | ...... | ...... |
| 17 | 9 | 6.3 | 4.1 | ...... | 51 | 111 | ...... | 51 | 49 | 75 | ...... | ...... |
| 18 | 9 | 6.2 | 4.1 | ...... | 49 | 104 | 75 | 68 | 95 | 88 | ...... | ...... |
| 19 | 9 | 6.1 | 4.0 | ...... | 43 | 102 | 72 | 66 | 49 | 75 | ...... | ...... |
| 20 | 8.7 | 6.0 | 4.0 | 5.2 | 43 | 86 | 70 | 111 | 36 | 64 | ...... | ...... |
| 21 | 8.7 | 5.8 | 3.9 | 6.5 | 41 | 75 | 66 | 100 | 30 | 59 | ...... | ...... |
| 22 | 8.7 | 5.8 | 3.9 | 8.7 | 38 | 64 | 59 | 114 | 27 | 53 | ...... | ...... |
| 23 | 9.3 | 5.6 | 3.8 | 8.5 | 38 | 68 | 55 | 160 | 51 | 48 | ...... | ...... |
| 24 | 9.9 | 5.5 | 3.8 | 8.7 | 43 | 81 | 55 | 118 | 38 | 44 | ...... | 26 |
| 25 | 9.9 | 5.4 | 3.7 | 9.0 | 51 | 192 | 51 | 94 | 111 | 40 | ...... | 27 |
| 26 | 10 | 5.4 | 3.7 | 9.0 | 62 | 111 | 48 | 94 | 440 | 31 | ...... | 33 |
| 27 | 10 | 5.3 | 3.6 | 9.0 | 73 | 97 | 66 | 147 | 184 | 31 | ...... | 28 |
| 28 | 10 | 5.2 | 3.6 | 9.0 | 272 | 90 | 75 | 131 | 114 | 31 | ...... | 27 |
| 29 | 9.9 | ...... | 3.5 | 9.0 | 210 | ...... | 57 | 151 | 90 | 42 | ...... | 25 |
| 30 | 9.9 | ...... | 3.5 | 9.2 | 121 | ...... | 59 | 220 | 70 | 86 | ...... | 24 |
| 31 | 9.7 | ...... | 3.5 | ...... | 97 | ...... | 64 | 304 | ...... | 90 | ...... | 23 |

NOTE.—Discharge estimated for following periods because of unsatisfactory operation of water-stage recorder: Jan. 1–3, Jan. 13–17, Mar. 11–28, Mar. 30–31, and Apr. 1–19 (mean discharge, 4.5 second-feet), by comparison with hydrograph for Gold Creek and climatic data for Juneau; May 1, June 29–30 (mean discharge, 105 second-feet), and July 1–17 (mean discharge, 75 second-feet), by comparison with records of flow for Grindstone Creek, and from maximum stages indicated by recording pencil; Nov. 9–30 (mean discharge, 50 second-feet) and Dec. 1–23 (mean discharge, 40 second-feet), by comparison with records of flow for Sweetheart Falls Creek, and from maximum and minimum stages indicated by recording pencil.

*Monthly discharge of Sheep Creek near Thane for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 14 | 8.7 | 10.3 | 633 |
| February | 9.5 | 5.2 | 6.92 | 384 |
| March | 5.1 | 3.5 | 4.26 | 262 |
| April | 9.2 | ...... | 5.91 | 352 |
| May | 272 | 9.5 | 63.6 | 3,910 |
| June | 192 | 64 | 103 | 6,130 |
| July | ...... | 48 | 69.3 | 4,260 |
| August | 304 | 41 | 86.4 | 5,310 |
| September | 440 | 27 | 76.4 | 4,550 |
| October | 116 | 31 | 65.2 | 4,010 |
| November | ...... | ...... | 62.9 | 3,740 |
| December | ...... | ...... | 37.7 | 2,320 |
| The year | 440 | ...... | 49.3 | 35,900 |

NOTE.—See footnote to table of daily discharge.

### GOLD CREEK AT JUNEAU.

Location.—At highway bridge at lower end of Last Chance basin, 200 feet upstream from diversion dam of Alaska Electric Light & Power Co. and one-fourth mile from Juneau.

Drainage area.—9.47 square miles (determined by engineering department of Alaska Gastineau Mining Co. from surveys made by that company).

Records available.—July 20, 1916, to December 31, 1918.

Gage.—Stevens continuous water-stage recorder on left bank at upstream side of highway bridge. A staff gage was installed September 19, 1916, on left wing wall of diversion dam 200 feet downstream and used in determining the time of changes in stage-discharge relation at the well gage.

Discharge measurements.—At medium and high stages made from gaging bridge suspended, at right angles to current, from floor of highway bridge; at low stages, made by wading near gage.

Channel and control.—Station is at lower end of a flat gravel basin three-fourths mile long. For 20 feet upstream from gage the stream is confined between the abutments of an old bridge, and for 15 feet downstream it is confined between the abutments of present bridge. For a distance of 130 feet farther downstream the stream is confined in a narrow channel which is not subject to overflow. Because of the steep gradient of channel opposite and for 150 feet below gage, a short stretch of the channel immediately below the gage acts as the control. The operation of the head gates of flume at diversion dam, 200 feet downstream, does not affect the stage-discharge relation at gage, but the swift current during high stages shifts the gravel in bed of stream, thereby causing changes in the stage-discharge relation.

Extremes of discharge.—1916–1918: Maximum stage, 6.8 feet September 26, 1918 (discharge estimated from extension of rating curve, 2,600 second-feet); minimum discharge, 0.9 second-foot March 26, 1918.

Ice.—Stage-discharge relation affected by ice in January, February, and March.

Diversion.—Water diverted at several points upstream for power development is returned to creek above gage, except about 20 second-feet for seven months (when there is a surplus over amount used by Alaska Electric Light & Power Co., which has prior right) and 1 second-foot the remainder of year, used by the Alaska-Juneau Gold Mining Co. A dam 200 feet downstream diverts water into the flume of the Alaska Electric Light & Power Co.

Regulation.—No storage or diversions above station regulate the flow more than a few hours in low water.

Accuracy.—Stage-discharge relation changed during periods of high water; 12 discharge measurements made during year, by use of which rating curves have been constructed applicable as follows: January 2–27, rating curve for period stage-discharge relation was affected by ice fairly well defined; April 18 to May 28, rating curve same as used October 9 to December 31, 1917, well defined; May 29 to June 24, fairly well defined; June 25 to September 26, fairly well defined below and poorly defined above 500 second-feet; September 27 to November 29, fairly well defined below and poorly defined above 500 second-feet; November 30 to December 31, poorly defined. Operation of water-stage recorder satisfactory except for periods indicated in footnote to daily-discharge table. Daily discharge ascertained by applying to rating table mean daily gage heights determined by inspecting gage-height graph, or, for days of considerable fluctuations, by averaging discharges obtained by applying to rating table mean gage heights for equal intervals of the day. Records fair.

*Discharge measurements of Gold Creek at Juneau during 1918.*

[Made by G. H. Canfield.]

| Date. | Gage height. | Discharge. | Date. | Gage height. | Discharge. |
|---|---|---|---|---|---|
| | *Feet.* | *Sec.-ft.* | | *Feet.* | *Sec.-ft.* |
| Jan. 2 | [a] 0.89 | 40 | June 7 | 2.45 | 248 |
| 18 | [a] .29 | 7.2 | July 23 | 1.59 | 144 |
| Feb. 11 | [b] .15 | 4.0 | Sept. 7 | 1.25 | 84 |
| 26 | [b] —.04 | 1.6 | 30 | 1.61 | 126 |
| Mar. 26 | ([c]) | .5 | Nov. 9 | 1.38 | 86 |
| Apr. 11 | .......... | [d] 2.0 | 27 | 1.26 | 66 |

[a] Deep snow and ice along shore and on bar in middle of creek; control open.
[b] Creek frozen over at gage; ice arched over at control.
[c] Well frozen solid; control frozen over.
[d] Discharge estimated.

*Daily discharge, in second-feet, of Gold Creek at Juneau for 1918.*

| Day. | Jan. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 30 | ........ | 16 | 85 | 222 | 134 | 219 | 110 | 129 | 143 |
| 2 | 37 | ........ | 16 | 59 | 182 | 114 | 158 | 123 | 88 | 100 |
| 3 | 18 | ........ | 84 | 78 | 166 | 114 | 126 | 228 | 70 | 70 |
| 4 | 16 | ........ | 84 | 96 | 160 | 105 | 107 | 300 | 63 | 48 |
| 5 | 12 | ........ | 101 | 137 | 170 | 114 | 95 | 154 | 272 | 39 |
| 6 | 12 | ........ | 92 | 238 | 248 | 158 | 83 | 105 | 700 | 34 |
| 7 | 10 | ........ | 72 | 264 | 307 | 162 | 93 | 96 | 272 | 31 |
| 8 | 9 | ........ | 69 | 244 | 307 | 123 | 71 | 93 | 109 | 28 |
| 9 | 8 | ........ | 89 | 252 | 304 | 112 | 56 | 88 | 85 | 27 |
| 10 | 8 | ........ | 119 | 241 | 239 | 102 | 272 | 80 | 79 | 25 |
| 11 | 8 | ........ | 132 | 213 | 225 | 96 | 141 | 73 | 73 | 24 |
| 12 | 8 | ........ | 132 | 213 | 219 | 91 | 90 | 88 | 68 | 22 |
| 13 | 8 | ........ | 118 | 181 | 234 | 187 | 68 | 143 | 63 | 21 |
| 14 | 8 | ........ | 105 | 216 | 266 | 119 | 65 | 209 | 58 | 20 |
| 15 | 8 | ........ | 89 | 224 | 239 | 119 | 83 | 139 | 53 | 20 |
| 16 | 8 | ........ | 87 | 211 | 228 | 170 | 112 | 107 | 48 | 20 |
| 17 | 8 | ........ | 79 | 213 | 248 | 124 | 180 | 123 | 45 | 32 |
| 18 | 7 | 16 | 76 | 222 | 231 | 151 | 352 | 147 | 39 | 28 |
| 19 | 7 | 39 | 69 | 200 | 192 | 208 | 138 | 110 | 35 | 27 |
| 20 | 7 | 23 | 62 | 152 | 192 | 314 | 85 | 88 | 48 | 25 |
| 21 | 7 | 15 | 62 | 137 | 187 | 345 | 59 | 76 | 80 | 24 |
| 22 | 11 | 12 | 55 | 122 | 160 | 377 | 48 | 69 | 133 | 28 |
| 23 | 17 | 12 | 54 | 145 | 160 | 615 | 140 | 64 | 102 | 32 |
| 24 | 14 | 11 | 62 | 208 | 168 | 535 | 102 | 58 | 91 | 32 |
| 25 | 12 | 10 | 79 | 555 | 143 | 435 | 375 | 49 | 79 | 35 |
| 26 | 10 | 10 | 103 | 310 | 128 | 415 | 1,520 | 39 | 66 | 33 |
| 27 | 9 | 10 | 128 | 291 | 206 | 454 | 523 | 32 | 73 | 24 |
| 28 | 8 | 11 | 432 | 236 | 245 | 515 | 214 | 30 | 80 | 20 |
| 29 | 7 | 15 | 335 | 288 | 141 | 575 | 152 | 54 | 272 | 18 |
| 30 | 7 | 15 | 165 | 331 | 139 | 635 | 129 | 177 | 158 | 16 |
| 31 | 6 | ........ | 102 | ........ | 216 | 328 | ........ | 242 | ........ | 16 |

NOTE.—Discharge estimated for following periods, because of unsatisfactory operation of water-stage recorder: Jan. 1, Jan. 27–31, Feb. 1–28 (mean discharge, 4 second-feet), Mar. 1–31 (mean discharge, 1 second-foot), and Apr. 1–17 (mean discharge, 2 second-feet) from discharge measurements, climatic records at Juneau, and by comparison with hydrograph for Sheep Creek; May 13, by interpolation; July 9–11, 1 p. m. Sept. 26 to Oct. 1, Oct. 5 to 13, Oct. 26 to Nov. 7, Nov. 10–16, Nov. 18–26, Nov. 28 to Dec. 4, and Dec. 6–20, by comparison with records of flow for streams in near-by drainage basins, and from maximum and minimum stages indicated by recording pencil.

*Monthly discharge of Gold Creek at Juneau for 1918.*

| Month. | Discharge in second-feet. | | | Run-off (total in acre-feet). |
|---|---|---|---|---|
| | Maximum. | Minimum. | Mean. | |
| January | 30 | 6 | 11.1 | 682 |
| February | | | 4.0 | 222 |
| March | | | 1.0 | 61 |
| April | 39 | | 7.8 | 464 |
| May | 432 | 16 | 105 | 6,460 |
| June | 555 | 59 | 212 | 12,600 |
| July | 307 | 128 | 209 | 12,900 |
| August | 615 | 91 | 260 | 16,000 |
| September | 1,520 | 48 | 195 | 11,600 |
| October | 300 | 30 | 113 | 6,950 |
| November | 700 | 35 | 118 | 7,020 |
| December | 143 | 16 | 34.3 | 2,110 |
| The year | 1,520 | | 106 | 77,100 |

NOTE.—See footnote to table of daily discharge.

# NICKEL DEPOSITS IN THE LOWER COPPER RIVER VALLEY.

By R. M. Overbeck.

## INTRODUCTION.

Nickel is one of the few metals for which the United States now depends on other countries. Its importance has been shown by the extensive uses to which it was put during the war, and consequently the discovery of deposits of nickel ore would be welcome additions to the knowledge of the mineral wealth of the United States. The purpose of the present investigations of the nickel deposits of Alaska is to accumulate data about the extent to which the United States can be independent of other countries for its supply of nickel. Such data are valuable, even if the deposits are never worked, because they may prescribe limits to the monopoly held by other countries. Unless a strong demand for nickel on the Pacific coast should arise through the establishment of industries in which nickel is used, the present known nickel deposits of Alaska probably could not compete, for their nickel content alone, with the deposits of Sudbury, Canada.

The nickel deposits near Spirit Mountain, in the lower Copper River valley, were visited in August, 1917, by the writer, who spent about one and a half days in examining the prospects. An occurrence of nickel in southeastern Alaska has been described in a previous report.[1]

## LOCATION.

The Spirit Mountain nickel deposits are near the head of Canyon Creek, a small westward-flowing stream that enters Copper River about 8 miles below the mouth of Chitina River. (See fig. 1.) The mouth of the creek, which is nearly opposite mile 121 on the Copper River & Northwestern Railroad, is about 9 miles south of the town of Chitina. Although Canyon Creek is only 12 miles long, it is fed by several large glaciers and consequently at times carries much water. Canyon Creek flows northeastward for 3 miles and, making a right-angled bend, northwestward for the remaining distance. The lower course of the stream lies in a narrow box canyon. The principal nickel deposit is on the west side of the creek about 1½ miles southwest of the right-angled bend and about the same distance from the head

[1] Overbeck, R. M., Geology and mineral resources of the west coast of Chichagof Island: U. S. Geol. Survey Bull. 692, pp. 91–136, 1919 (Bull. 692–B).

of the creek. The main exposure is on a steep hillside several hundred feet above stream level, or approximately 4,000 feet above the sea.

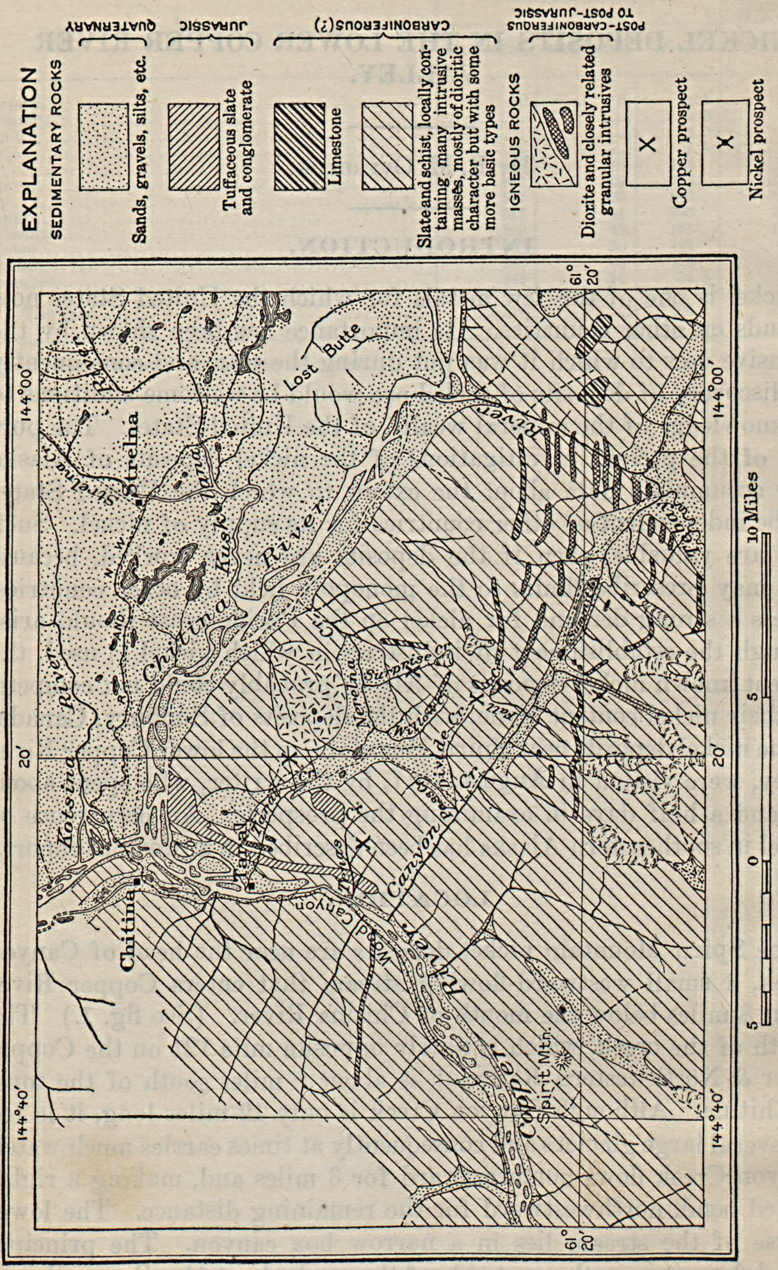

FIGURE 1.—Geologic reconnaissance map of Canyon Creek and vicinity.

The deposits, though they derive their name from the prominent peak on Copper River known as Spirit Mountain (elevation 7,270 feet), lie about 12 miles east of the peak.

The claims can be reached from Chitina by two trails. One trail leaves the east side of Copper River at Taral; the other, at a point a short distance below the mouth of Canyon Creek. The Canyon Creek trail is the one most used now, for it is reported to be in somewhat better condition than the Taral trail. The Canyon Creek trail is steep, rising 2,000 feet in a little over a mile, but at the time of visit the footing for horses was good in all except one place. The distance to the claims from the river is about 12 miles. By either trail a crossing of Copper River is necessary, but boats and Indian boatmen can usually be hired for the trip. Horses have to swim, as the river is narrow and swift at both crossing places.

The nearest town to the deposits is Chitina, which lies near Copper River, opposite the mouth of Chitina River, about 9 miles above the mouth of Canyon Creek. Supplies can be obtained at Chitina, or from Cordova, the nearest seaport and the coast terminus of the Copper River & Northwestern Railroad, 130 miles from Chitina.

The region is extremely rugged. Copper River has an elevation of 400 feet just below the mouth of Canyon Creek, but the mountains on either side of the river rise steeply to elevations of 6,000 feet or more. Many of the streams flow through deep canyons just before entering Copper River, and most of them are fed by glaciers. Timber line averages 2,500 feet above sea level. The Spirit Mountain deposits are several miles from the nearest timber. A more detailed discussion of the geography of the region is given by Moffit.[1]

## GEOLOGY.

The following notes on the geology of the region in which Canyon Creek lies are quoted or abstracted from the report by Moffit[2] on the Hanagita-Bremner region:

> Two groups of sedimentary rocks occupy most of the area under consideration. The oldest consists of schist, slate, and limestone, which form the chief rocks of the mountains between Hanagita Valley and Chitina River and of those south of the Hanagita Valley eastward from Copper River for nearly 30 miles. These sedimentary beds are folded, faulted, and much metamorphosed. Furthermore, they are intruded in a most complicated manner by igneous rocks and sills, which are chiefly dioritic but include granitoid rocks of a more basic kind. * * *
>
> The second group of sedimentary beds consists of interstratified slate and graywacke, here classed as early Mesozoic (?) (Valdez group). It adjoins the group first mentioned on the south. * * * These sedimentary rocks are folded and faulted but are less metamorphosed than the schist and limestone beds bounding them on the north. They are cut by numerous light-colored dikes of quartz monzonite.

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[1] Moffit, F. H., Geology of the Hanagita-Bremner region, Alaska: U. S. Geol. Survey Bull. 576, p. 8–17, 1914.

[2] Idem., pp. 17–18, 32–33.

Igneous rocks are common throughout this district. Diorite and closely related types are the most common, but more basic intrusive rocks are found in several places. The dioritic rocks doubtless belong to several periods of intrusion. Some of them are light colored, coarse grained, and almost unaltered; others are fine grained and dark colored. Diorite is especially common in the vicinity of Taral and is in places so greatly altered that it can not be readily distinguished from the altered diabase associated with it. The greenstone so abundant east of Taral is derived from diorite and diabase. A very few basic dikes having the composition of peridotites were found in this vicinity. The small area between Canyon Creek and Chitina River is in large part a complex of intrusives in which large masses of sedimentary rock have been inclosed. Diabase is the prevailing type, but diorite is common and presents a varied appearance. A dike of peridotite consisting of pyroxene and much-altered olivine with metallic sulphides was found near the head of Canyon Creek. The surrounding rocks are schist and limestone, very much folded and extensively faulted.

The country has been extensively glaciated.

## THE DEPOSITS.

Up to the time of the writer's visit in 1917 sixteen nickel claims had been located in the Canyon Creek valley. Some of these claims were staked as early as 1907 or 1908. Moffit, who in 1911 visited the deposits on the west side of the creek, has described them briefly, and apparently little development work has been done on them since that time. The 16 claims, which are consolidated, are held by three or four men. Six of these claims are on the west side of Canyon Creek near its head, 4 on the east side, 4 just over the ridge on the east side, and 2 opposite the mouth of Fall Creek on the ridge along the south side of Canyon Creek. The principal development work has been done on the claims west of Canyon Creek. At the time of visit in 1917 no work was being done on any of the claims.

The country rock of the Canyon Creek valley is schist of probable Carboniferous age. The numerous bodies of igneous rock that have intruded the schist are conspicuous because of their rusty-looking croppings. The shapes of these bodies are irregular, but the irregularity is probably due in part to faulting which took place after intrusion. The slickensided surfaces found along the contact between schist and igneous rock indicate that such faulting has occurred, and a fault trace shows prominently on the face of a cliff on the west side of Canyon Creek. The intrusive bodies range from acidic rocks, such as quartz monzonite, to basic rocks, such as peridotites. Quartz stringers are also rather abundant in the schist.

The most promising of the exposures and the one on which the most development work has been done is on the west side of Canyon Creek about 500 feet above the bed of the creek, or 4,100 feet above sea level. Some shallow pits have been sunk on the outcrop, and a 50-foot tunnel has been driven in an attempt to undercut the ore body. Several other holes have been put down to find the continuation of the body up the hill. The outcrop of the body is plainly visible from the creek, for one end of it is cut off by a cliff, and the face of this cliff is stained a bright yellowish brown and green. As exposed at the surface the ore body is an irregular mass about 25 feet wide, which strikes about N. 65° W. and apparently dips very steeply to the north. The westward extension of this body can be traced only a short distance on the surface, and its eastward extension is cut off within a short distance by a steep cliff. The section of the body outlined on the cliff face has a width of about 25 feet for possibly 50 feet down the cliff and is there cut by a fault. An iron-stained streak a foot or more wide follows the fault trace down the cliff. At the bottom of the cliff a tunnel has been driven into a crushed zone about a foot wide which includes with the crushed material a little mineralized basic rock. The face of the cliff is inaccessible, and so absolute measurements of the exposures there could not be made.

The country rock in which the nickel-bearing body occurs is light-gray limy and quartzose schist, striking N. 84° W. and having a vertical dip, into which peridotite has been intruded. The peridotite is rather strongly mineralized in places with sulphides, and it is with these sulphides that the nickel is associated. This schist, which is a recrystallized impure limestone, is seen under the microscope to consist chiefly of coarse calcite crystals separated by flakes of biotite, chert, hornblende, muscovite, and zoisite. Along the hanging wall of the ore body lies a light-colored igneous rock that may represent an acidic differentiation product of a magma of which the nickel-bearing basic rock along the footwall is the other extreme. This acidic rock is very light colored and medium grained and contains a few scattered garnets. A thin section shows that it consists chiefly of quartz, orthoclase, and altered plagioclase. The quartz and orthoclase together are about equal in amount to the altered plagioclase. Some garnet and a few flakes of biotite and muscovite are present. The altered feldspar has been so far changed that its original composition could not be determined, although traces of plagioclase twinning can still be detected in some of the crystals. The alteration product of the feldspar is very fine grained and can not be determined definitely, but a considerable part of it seems to be sericite. The quartz and orthoclase are closely intergrown and

in some parts of the slide show graphic intergrowth. Attention is called to this graphic intergrowth because, although it is extremely common in the acidic rocks, it has been noted at a number of places where nickel ores are associated with extremely basic igneous rocks. Relatively the rock is not greatly altered, nor does it show the effects of having undergone any intensive squeezing. As the specimen was taken from a surface outcrop, much of the alteration may be due to weathering. Stringers of chlorite are rather common, but these too may be the result of weathering.

The quartz stringers, which are fairly abundant near the outcrop of the basic rock, may represent products of differentiation—a step farther than that of the acidic dike.

The rock in which the nickel-bearing sulphides occur is a highly altered coarse-grained peridotite. It appears to have consisted originally of olivine and pyroxene, but it has been so greatly altered that none of the olivine and almost none of the pyroxene remains. The olivine has been altered with characteristic mesh structure to serpentine, talc, and opaque minerals. The pyroxene is now hornblende. Some epidote and several large flakes of biotite were noted. Stringers of carbonate that may be in part calcite and in part magnesite are very abundant in the slide.. Chlorite is present in considerable quantity. The rocks as a whole, however, have been so greatly altered that only a part of the minerals can be definitely determined. The opaque sulphide minerals in the slide occur partly as grains and partly as stringers that cut across the silicates. Although the sulphides seem to be later than the silicates, their deposition seems to have been controlled to some extent by the presence of the silicates. In other words, they are for the most part interstitial between the grains of the silicates and to a rather minor extent cut across the grains. Although the type of rock is different from that of the southeastern Alaska nickel deposit, the texture of the polished surface of the ore rock is very similar in appearance. Chalcopyrite and pyrrhotite can be recognized in a thin section of the ore rock.

The more heavily mineralized portion of the dike is along its footwall side. In places the mineralized rock is massive sulphide, but at most places where it has been mineralized the sulphides are interstitial in the coarse-grained igneous rock. The minerals in the massive ore have been acted on extensively by the weather and now represent rather an agglomeration of original minerals and minerals that are the result of weathering. The only mineral that can be definitely determined on a polished surface of the ore is chalcopyrite. The section is cut by numerous stringers of a bluish mineral that may be in part chalcocite and in part hematite. The most abundant minerals in the slide have some resemblance to pyrrhotite, but comparison with polished surfaces of known pyrrhotite show there is a decided

difference in color. The most abundant mineral, next to pyrrhotite, in most of the specimens is light colored and has roughly equidimensional surfaces that show cubic cleavage. This mineral occurs also in slender stringers cutting though the pyrrhotite. The pyrrhotite is very strongly magnetic; the unknown mineral is nonmagnetic.

The sulphides are so brittle and so badly weathered that a good polished section on which the relations of the opaque minerals can be seen is difficult to get. Stringers of a bluish mineral that seems in part to be hematite are abundant in the section. These stringers are later than the other minerals in the section. Marked cleavage occurs in the pyrrhotite, and in places the bluish mineral follows these cleavage lines. With high powers of the microscope minute parallel cleavage lines can be seen starting out on either side of the cracks that cut the polished surface. Chalcopyrite is scattered through the slide and varies in amount in different specimens. The order of deposition of the three minerals can not be told from the highly polished specimens. The unknown mineral seems to be present both as crystals and as stringers.

An attempt was made to determine the two principal minerals that were observed on a polished surface of the ore. In order to get material, if possible, that would be homogeneous a piece of the ore was cut into many thin slices. The slices were polished on both sides so that the minerals could be recognized and picked out. After the material was selected in this way it was ground very fine, and a further separation was made with a magnet. The result of the chemical analysis is as follows:

*Analyses of minerals from nickel ore of Spirit Mountain deposits.*

[W. T. Schaller, analyst.]

| | 1 | 2 |
|---|---|---|
| Insoluble in aqua regia | 1.2 | 0.9 |
| Soluble in HCl: | | |
| Cu | .2 | .3 |
| Fe | 9.8 | 53.2 |
| Ni | 3.2 | 2.2 |
| Insoluble in HCl: | | |
| Cu | .5 | .3 |
| Fe | 18.6 | .9 |
| Ni | 16.4 | .0 |
| S (by difference) | 50.1 | 42.2 |
| | 100.0 | 100.0 |

Mn, Zn, Co, and As absent. 1, Supposed nickel mineral; 2, supposed pyrrhotite.

The above analysis shows that both specimens, notwithstanding careful mechanical separation, are mixtures. Specimen 2 consists essentially of iron and sulphur and is probably pyrrhotite, as was originally supposed. Nickel and copper are probably impurities. That the presence of copper would be shown in the analysis was expected, for, as stated above, chalcopyrite and chalcocite (?) were

determined in the hand specimen. Some of the iron, too, is undoubtedly derived from hematite and limonite. In specimen 1 there are apparently two kinds of nickel minerals, one soluble in hydrochloric acid and the other insoluble. Their formulas and consequently their names can not even be surmised, for the extent to which impurities have entered into the analysis is not known; nor is it possible to determine the influence of the ferric chloride that was formed when part of the material went into solution on the solubility of the material not in solution.

The iron-stained outcrops on the east side of the creek reach 100 feet in width, but their outline is irregular. They occur in a country rock of schistose impure limestone. Such outcrops can be traced intermittently up the hillside and over the ridge, and they may have at one time belonged to a single body that has since been broken by faulting. At several places in these croppings shots have been put in, but there are no satisfactory exposures of the fresh underlying rock. Some stringers of pyrrhotite were found at places, but analysis of this pyrrhotite showed only a trace of nickel.

It is reported that the best assay returns obtained from the Canyon Creek claims showed about 11 per cent of nickel and about 2 ounces of silver to the ton. A selected specimen of the sulphide ore was analyzed in the laboratory of the Survey and reported to contain 7.23 per cent of nickel and a trace of cobalt. One of the principal things to be determined about the deposit is whether the nickel is a surface concentration or whether the tenor holds or increases with depth. To determine this point further development work and additional assays are necessary. All the specimens that are now available show the effects of extensive surface alteration.

The amount of development work done on the claims is so small that assay returns as to the amount of nickel in the ores may be misleading. Weathering, for example, may have leached and carried away much of the nickel, or it may have concentrated the nickel under the leached surface cropping. Most very basic dikes, such as peridotite dikes, carry a small percentage of nickel, and surface leaching and reconcentration of this nickel may cause an enrichment near the surface that would give an erroneous idea of the true tenor of the body. Some fresh pyrrhotite taken from one of these dikes was tested for nickel and showed only the most minute trace. The deposits in New Caledonia represent the type of nickel deposit which is formed from the surface enrichment of basic igneous rocks. Such deposits, to have economic value, must be rather large and so disposed that surface stripping could be carried on easily.

# PRELIMINARY REPORT ON THE CHROMITE OF KENAI PENINSULA.

By A. C. Gill.

## INTRODUCTION.

The chromite deposits of Kenai Peninsula are situated at two localities near the southwestern extremity of the peninsula. (See Pl. I.) One of these deposits forms the rocky peninsula called Claim Point, at the entrance to Port Chatham, where the townsite named Chrome has recently been located, and extends for a short distance onto the adjacent mainland of the peninsula. It is thus practically at tidewater. The other is 16 miles to the northeast, at Red Mountain. Chrome ore has been produced only at Claim Point. Nearly a thousand tons from this locality in 1917 and approximately the same amount in the season of 1918 seem from available records to constitute Alaska's entire contribution to the chrome industry. Previous publications on these deposits include reports by Grant,[1] who visited both areas in 1909, noted the character of the igneous rock, and mentioned two of the chromite deposits; by W. P. Lass,[2] of the firm Whitney & Lass, owning and operating the Claim Point property, who has published a statement of the quantity, quality, and conditions of shipment of his firm's product for the season of 1917; and by J. B. Mertie, jr.,[3] who in the summer of 1917 gathered data concerning the chromite at both localities. The following pages include the more important economic conclusions derived from a detailed study of these chrome-bearing areas made during the season of 1918. A more extended account of these investigations is in preparation.[4]

## GEOLOGY.

The country rock in which the chromite occurs consists of masses of dunite, which are surrounded by beds of more or less metamorphosed clastic rocks, chiefly slates and graywackes. The metamorphic

[1] Martin, G. C., Johnson, B. L., and Grant, U. S., Geology and mineral resources of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. 587, p. 237, 1915.

[2] Lass, W. P., Chrome deposits of Alaska: Min. and Sci. Press, Nov. 3, p. 653, 1917.

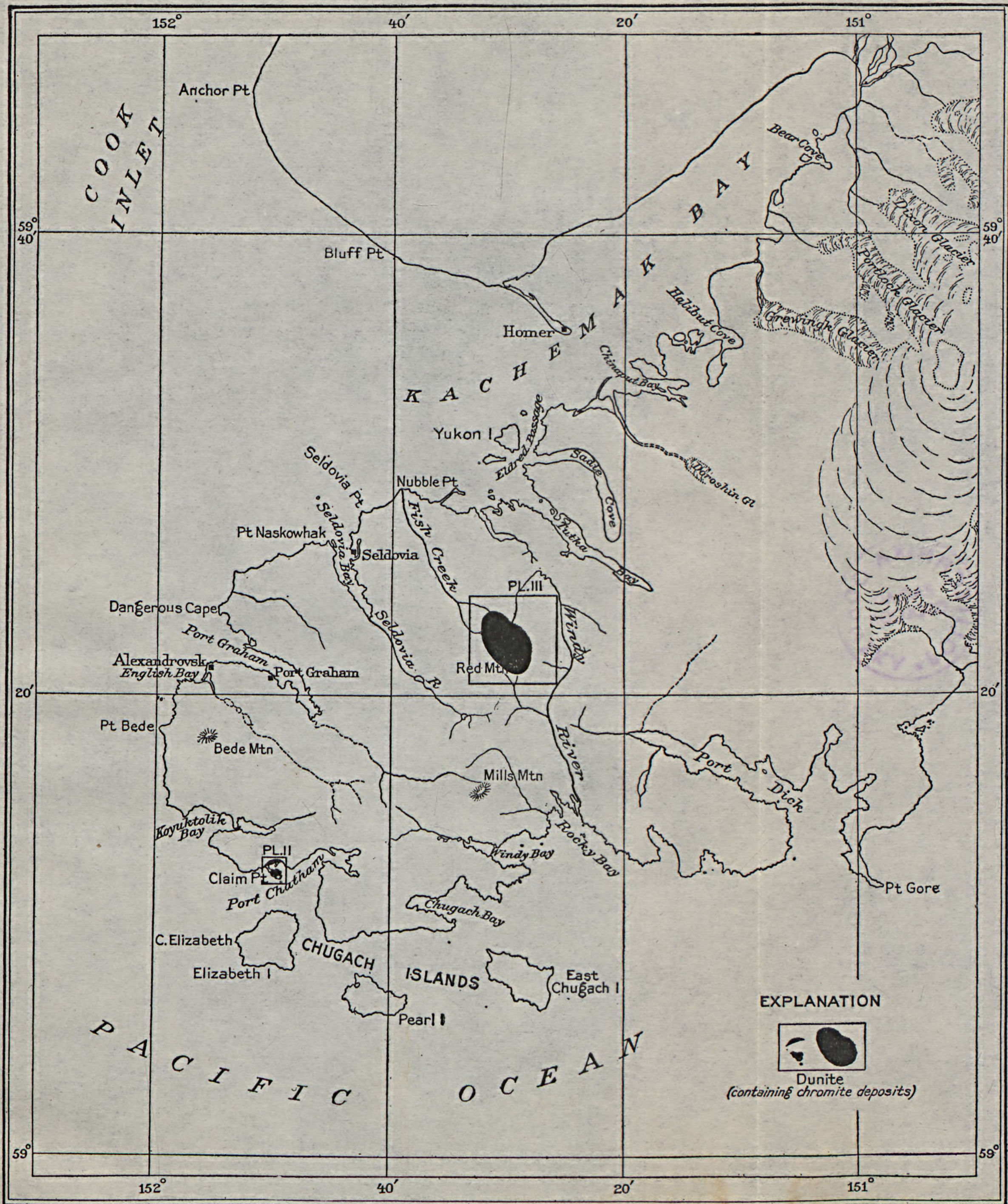
[3] Mertie, J. B., jr., Chromite deposits in Alaska: U. S. Geol. Survey Bull. 692, pp. 265–267, 1919.

[4] Gill, A. C., Chromite of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. — (in preparation).

rocks include black slates, cherts with quartz veinlets, graywacke of sandy or arkosic composition, and graywacke with lenticular carbonate layers, containing included shale fragments or presenting a marked "greenstone" aspect. The general characteristics of these rocks are described by Martin, Johnson, and Grant in Bulletin 587. The alterations of these rocks near the dunite contacts are in general slight, certainly much less than appears in rocks lithologically similar at their contacts with the diorite near Point Bede and south of the entrance to Koyuktolik Bay.

The mass of dunite at Claim Point is so nearly surrounded by water that its exact boundaries and dimensions can not be given. It doubtless occupies the whole of the Claim Point hill, for it is exposed around the entire base of the hill, either along the shore or in a low bluff rising from the grass flats to the northwest. It probably also underlies these grassy flats, a portion of which forms the narrow neck connecting Claim Point with the mainland of Kenai Peninsula, and it is exposed along the base of the mountains on this mainland at many points, the most widely separated of which are three-quarters of a mile apart. The dunite does not show along the base of the main ridge west of the Claim Point neck, though the metamorphosed condition of the rock just west of the junction of this neck with the mainland may indicate its proximity. The extreme observed distance between exposures in an east-west direction is almost exactly a mile and in a north-south direction seven-eighths of a mile as shown on the accompanying map (Pl. II). The dimensions of the dunite mass are of course greater than this.

The dunite area at Red Mountain is somewhat elliptical in shape. Its length from northwest to southeast is about 4 miles, and its width only 2 miles. Its area is approximately 7 square miles. (See Pl. III.) The main summit of Red Mountain is near its southeast end, forming part of a dunite ridge which is shaped like a somewhat distorted horseshoe with its opening toward the north, through the valley of Windy River. The boundaries of the igneous mass may be approximately followed with the utmost readiness, uncertainty arising only at the outlets of cirques where former glaciers have deposited their pluckings from the highly jointed dunite. Except by the roundabout course of Windy River, passage from the inner basin to the outer slopes of the horseshoe ridge can not be found at altitudes less than 2,150 to 2,700 feet. Transportation to tidewater (see p. 126) thus becomes a very different problem for the different parts of the area, though the distance necessary to be traversed may be nearly the same.




MAP OF WESTERN PART OF KENAI PENINSULA SHOWING CHROMITE DEPOSITS AND POSITION OF DETAILED MAPS.

## ORE DEPOSITS.

### GENERAL FEATURES.

The outstanding peculiarity of the Kenai Peninsula chromite bodies is their continuity for considerable distances in the shape of bands or layers, as contrasted with the "pockety" character exhibited by such ores at most localities. This extension in the layers is not so pronounced at Port Chatham as in the Red Mountain region, though even here it is unusually well developed. Two typical cases may be cited in order to give definiteness to this statement.

At the Reef mine, at Claim Point, the length of the deposit is about 135 feet. At the east end its thickness is about 3 feet; a section measured near the middle showed 47 feet 4 inches; and another toward the west end 23 feet 2 inches. The thickness near the middle is thought to be approximately doubled by faulting. All these measurements include more or less rocky material, occurring in parallel banding with the chromite.

The most extended ore body observed in the Red Mountain district is on the Star Chrome No. 4 claim. Its width ranges from 6 to 11 feet for a distance of more than 600 feet, and it is continued for at least 500 feet more to the north in the form of separate stringers some of which are a foot or so in thickness. Smaller stringers are numerous at many places where there is no workable ore. Some were noted with a thickness of a quarter of an inch and a length of 2 feet; some 2 inches thick and 8 or 10 feet long. All show the same general layer-like shape.

The chrome ores of both districts are highly variant in appearance. Two pronounced types are chosen for purposes of description, though intermediate forms are quite as abundant as these. One is a granular black massive rock, with lustrous surfaces where freshly broken, becoming dull brown through attrition of the fragments. The other is a banded variety, in which light and dark layers in parallel or nearly parallel position present a striking color contrast. The layers in the banded ores range from less than a twentieth of an inch to several inches in thickness, though on closer inspection the wider bands usually appear to possess a certain degree of subsidiary banding with more indistinct boundaries between the light and dark colored portions. The dark constituent is chromite, and the light-colored part is usually olivine, which is doubtless very low in its iron percentage, or much more rarely a light-green monoclinic pyroxene, which may prove on further study to be chromiferous and may be similar in origin to the pyroxenite bands in the dunite.

The mineral composition of the chrome ores is very simple. They are mixtures of chromite and olivine in all proportions, with accessory pyroxene at a few localities. Possibly some of the peripheral masses may be found to contain serpentine or other weathering products instead of olivine.

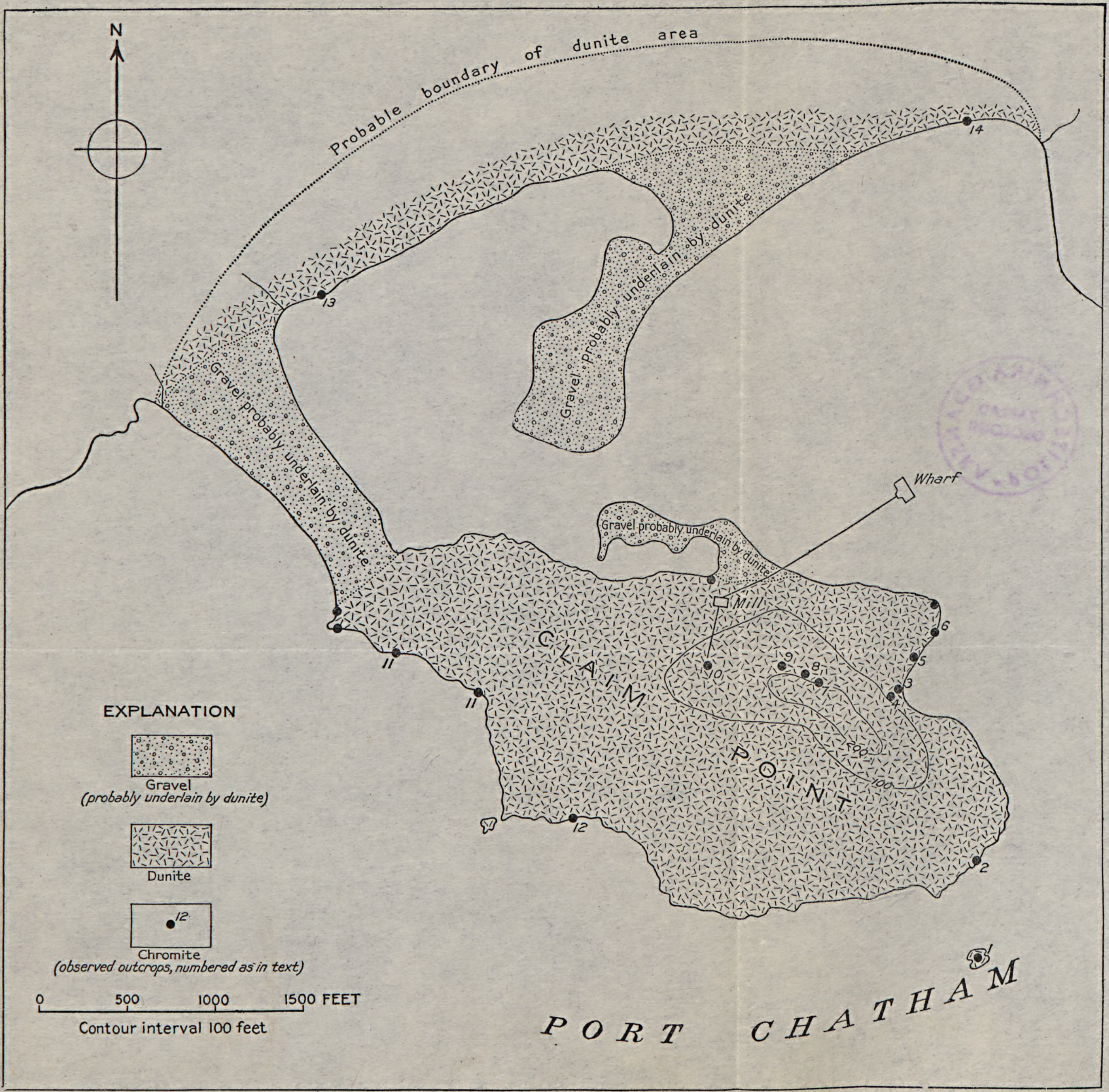
## PORT CHATHAM.

### DEPOSITS.

Fourteen separate deposits which under normal market conditions might yield more or less chromite were observed. As will be shown in the later discussion, this number is by no means exact. For example, in the high sea wall at the head of the cove near the northwest end of Claim Point hill no less than eight separate patches of banded ore are visible. Three of these show plainly that they are faulted portions of what was originally a continued set of stringers. On the whole, it seems probable that the eight or more separate masses are dislocated portions of two stringer systems, about 30 feet apart and in parallel position, and hence in enumerating the fourteen deposits these were counted as two. The deposits on the hill to the west are believed to be continuations of the same two bands, yet they are counted as three more because definite evidence of their continuity is lacking, and in any event the connecting portions may very likely not be of workable quality.

The masses of chromite occur chiefly in bands or layers or composite series of layers ranging from a fraction of an inch to 40 feet or more in thickness and from 3 or 4 inches to more than 200 feet in length. These chromiferous bands are in some places composed of massive granular chromite, in others of more or less disseminated grains and octahedral crystals distributed in maximum abundance along parallel roughly plane surfaces. The characteristics of these ore bodies may perhaps best be presented by describing in some detail each that seems capable of furnishing marketable ore, even though the quantity may not be large. The positions of such ore bodies are indicated on Plate II.

**1.** On a small island which lies southeast of Claim Point hill and which at low water is connected with the mainland by a narrow rocky neck is the Reef mine, operating on the ore body from which most of the chromite thus far shipped from Alaska has been taken. The strike of this ore mass is S. 76° W. and its dip nearly vertical, though the component ore bands show much local variation in dip and strike. Its length is about 135 feet and its width varies from 3 to perhaps 35 feet. A section across the main heading at high-tide level was measured on July 9, 1918, as follows:




MAP SHOWING CHROMITE DEPOSITS AT CLAIM POINT, PORT CHATHAM.

*Section at main heading, Reef mine.*

| | Ft. | in. |
|---|---|---|
| Dark ore, 40 per cent | 6 | 0 |
| Rock | 1 | 2 |
| Mostly black, with 5 or 6 inches half silicate | 2 | 3 |
| Mostly waste, containing some chromiferous bands | 1 | 7 |
| Black ore with 2-inch diagonal "dike" | 2 | 0 |
| Massive black ore | 2 | 2 |
| Waste | 2 | 6 |
| Half and half | 1 | 0 |
| Waste | 1 | 0 |
| Half chromite in wedge-shaped bands | 5 | 5 |
| Massive ore, good to medium quality | 11 | 1 |
| Mostly waste | 6 | 3 |
| Shipping ore | 1 | 0 |
| Waste | 2 | 6 |
| Good ore, 40 per cent | 1 | 5 |
| Scattered stringers, no sharply defined wall. | | |
| | 47 | 4 |

Faulting has doubtless increased the apparent thickness along this line, probably by at least 10 feet, and for a conservative estimate of quantity it may be considered that the following section shows its normal magnitude:

*Section 50 feet southwest of main heading, Reef mine.*

| | Ft. | in. |
|---|---|---|
| 35 per cent ore | 2 | 9 |
| Waste | 6 | 6 |
| Shipping ore 40 per cent or better | 7 | 11 |
| Disseminated ore, 15 to 20 per cent | 6 | 0 |
| | 23 | 2 |

The highest point on the good ore between these two measured sections is about 18 feet above mean low tide. There is some poor ore 5 to 10 feet higher still to the southeast of the main lode. The depth below water level, according to the assumption that it is half of the horizontal length, would be 65 to 70 feet. The impression of the mine operators that this mass of ore is becoming larger at greater depths seems to be corroborated by Mertie's measurement of 20 feet for the maximum thickness in 1917 as compared with 23 to 34 feet in 1918, and by a divergence of perhaps 5° or 10° in the walls. As will be shown in the tonnage estimate, the part of the ore below tide at the Reef mine is doubtless greater than that above, even without assumption of increasing thickness at the lower levels.

The content of chromic oxide in this ore reached 46 to 49 per cent in the product of 1917. In the season of 1918 the operators found it advantageous to approximate a 40 per cent ore, on account of market conditions, their contracts not providing for a higher unit value for

richer ores. It is thus no indication of a deterioration in the quality of the ore that the later shipments have not maintained the percentage of the first season. During both years a certain amount of low-grade ore has been broken and not used which will be available for concentration when the mill is in operation.

**2.** In the low sea wall just east of the miners' quarters, which are near the shore about north of the Reef mine, is a small exposure of chromite 15 to 20 inches thick and about 20 feet long. The ore is in part of shipping grade and has been worked to a slight extent, chiefly for exploration. The strike is N. 70° E. and the dip nearly vertical. A smaller mass to the east may well be, as suggested by Mertie, a faulted part of the same deposit, but it seems not to be of workable magnitude.

**3** and **4.** In the high sea cliff at the head of the bight northeast of Claim Point hill is an inaccessible exposure of what seem to be two much disrupted stringer systems of banded chromite probably originally parallel and some 30 feet apart. Their thickness is estimated at 3 or 4 feet, and their vertical extent at 50 or 60 feet. The ore appears to be mostly of low grade, though some of the fallen fragments are judged to contain at least 30 per cent of chromite oxide. At the base of the cliffs at a distance of less than 50 yards in both directions from the main exposure are many chromite stringers of very low grade. Their original continuity with the higher masses is extremely hypothetical, yet the shattered condition of the country rock is such as to suggest faulting, and with the probability that the vertical component of the throw is here, as at the Reef mine, much greater than the horizontal component, the change in character of the deposit is not greater than might be expected.

**5.** About 75 yards north and east from the high wall just mentioned is a set of very irregular lenses and stringers of chromite exposed for a height of 25 feet just above the beach. At the bottom are small stringers, but in the middle there is some shipping ore, though even in this part concentrating ore is much more abundant. The maximum thickness is nearly 20 feet, perhaps through repetition of a smaller body by slipping and faulting. A little of this ore has been shipped

The associated rock is serpentine of a brownish color, which appears to be especially thoroughly weathered on account of its proximity to the fault zone and consequent free access of water.

**6.** At 50 yards east of No. 5, below high-tide level, is a sharply bounded lens of massive chromite exposed at low tide for a length of about 60 feet and a maximum width of 26 inches. For only 24 feet, however, is its width above 7 inches. Its strike is N. 86° W., which would carry it very near to the last-mentioned deposit. Under

the action of wave-driven pebbles and boulders it has proved less resistant than the dunite walls, so that it is exposed in the bottom of a small gully. This gully can be seen to continue for some distance under water, indicating a greater extent than is actually exposed. Shifting sand and gravel fill this eroded notch at times, completely covering the ore, as was observed on a second visit to the locality. This chromite was found to have a specific gravity of 4.37 to 4.44, and a sample analyzed by Chase Palmer in the chemical laboratory of the United States Geological Survey gave 46.84 per cent of chromite oxide. A white mineral in the cracks of this ore appears to be aragonite.

7. On the upper slope of the hill about 150 yards N. 76° W. from deposits Nos. 3 and 4 is a pit made for the purpose of developing one of the banded stringer systems of low-grade chromite. This pit is about 30 feet long, showing an ore-bearing width of 118 inches at the east end and 128 inches at the west (upper) end. The strike of the bands is N. 69° E. and their dip about 70° SE. The best of this ore for a thickness of 6 feet is estimated to carry 25 to 30 per cent of chromic oxide, and the remaining 4 feet or more averages perhaps half as much. The silicate constituent is partly monoclinic pyroxene of a greenish color, in places occurring as $\frac{1}{8}$-inch dikes cutting diagonally across the ore bands, and partly a light-colored olivine which weathers to a rusty yellow color.

About 100 feet S. 76° E. from the pit in a direct line toward the exposures in the sea wall is a natural exposure of many chromite stringers, which may be a continuation of the same deposit, faulted and displaced toward the south from that portion uncovered in the excavation. In order to express the legitimate doubt as to the continuity of these exposures the length of the ore body may be reduced one-half, namely, to 65 feet, in estimating its magnitude.

8. In another test pit 40 feet northwest of No. 7 a similar ore body is exposed for a length of 50 feet but is less sharply defined in its banding. It maintains the same strike and has a dip of about 80° SE. Its cross section shows 80 inches of ore, three samples from which have a specific gravity of 3.62 to 3.7, averaging 3.66, while on each side of this is poorer ore for a thickness of 2 to 3 feet. From the specific gravity of this ore, on the assumption that 3.3 is the density of the silicate constituent and 4.4 that of the chromite, somewhat more than 39 per cent of the better portion of the deposit is chromite, carrying approximately 20 per cent of chromic oxide. The inferior ore nearer the contacts is judged to be about half as rich.

Another development pit about 90 feet to the southwest is believed to be on the same ore body, though slightly offset to the right. The

strike of the bands is still N. 69° E., and the dip is nearly vertical. The exposed cross section measures 25 feet, and the ore is mostly of similar quality to that just noted, though in the southeasterly part of the pit the ore bands seem to be more sharply segregated from the rock, showing 12 or more bands of black, high-grade ore ranging from 1 inch to 2½ inches in thickness. The thicker bands may furnish a small amount of shipping ore. The total length of the ore mass is probably more than is indicated by the two excavations—that is, 140 feet, for a considerable number of rich chromite stringers ranging from half an inch to 4 inches in thickness occur nearly on the strike at a distance of 125 feet to the northeast. The width of the ore bands for the distance exposed by the two pits may be taken as 18 feet, for it is 11 feet in one and 25 feet in the other.

**9.** On the hillside 60 feet about N. 20° W. from the westerly opening on No. 8 is a rich chromite lens 4 inches wide and 4 or 5 feet long. It is accompanied by many smaller chromite stringers on both sides. It is doubtful if this is a portion of a workable deposit. It is interesting on account of a small fault that displaces the ore about 6 inches, indicating the presence of fractures in this region. There seem to be scattered stringers over a considerable width here, as in an opening 60 feet farther down the hillside in a direction N. 20° W., which was made with the intention of crosscutting by a tunnel to ore body No. 8, are exposed a few small ore bands. The strike of all these bands is about N. 70° E. and the dip nearly vertical.

**10.** What seems to be the largest chromite deposit at Claim Point—if, indeed, it is not part of an originally continuous mass 1,200 feet or more long connecting bodies Nos. 3 and 4 by way of Nos. 7 and 8 with this outcrop—is about 500 feet N. 68° W. from the west end of No. 8 and a little lower on the hill slope. It is thus offset about 250 feet to the right from the line of strike of the higher ore. Nothing more definite as to their original continuity can at present be offered than the observation that many small faults have been observed in the region, all with displacement in such sense as to indicate continuity if the proper amount of throw were present either in small steps or in one or more larger breaks.

This ore body is the central point in the plans for immediate future development. From it the tramway starts, and ore bins, mill, and wharf have been placed with reference chiefly to the handling of its output.

The ore body was only very slightly exposed by natural outcrop, and even when it was visited for the purposes of this report, development work had not progressed sufficiently to afford a clear view of its magnitude. A partly uncovered cross section at the end of the tramway up an irregular slope gave the following figures:

*Section at end of tramway on deposit No. 10.*

| | Ft. | in. |
|---|---|---|
| 15 per cent $Cr_2O_3$ (?) | 5 | 5 |
| 35 per cent $Cr_2O_3$ | 4 | 7 |
| 5 per cent $Cr_2O_3$ (too rocky to work?) | 2 | 2 |
| 50 per cent $Cr_2O_3$ | | 8 |
| 35 per cent $Cr_2O_3$ | 10 | 0 |
| Covered by soil and vegetation | 18 | 0 |
| 50 per cent $Cr_2O_3$ | 1 | 6 |
| | 47 | 9 |

In this cross section the ore estimated at 25 per cent chromic oxide is by no means homogeneous but is made up of streaks of poorer and richer material. Two chips from a specimen collected to represent its average quality gave specific gravities of 3.79 and 4.03, or an average of 3.91. On the assumptions that the specific gravity of the silicate constituent is 3.28, as found for the purest of the silicate rock (as a matter of fact this rock contained a little chromite), and that the chromite has a specific gravity of 4.4, the ore tested would contain 63 per cent of chromite. If either the silicate mineral or the chromite actually has a lower specific gravity than is above assigned, the percentage of chromite must be greater. Both these conditions are very probable, because, (1) as above noted, some chromite was present in the silicate material on which the determination of specific gravity was made, and furthermore the silicate portion of the ore appears somewhat dull as if partly hydrated, and (2) the blackest pieces of the chromite show a specific gravity of only 4.17, though not more than 10 per cent of the fragments used appeared to be silicate.

The position of the bands is more irregular than in most of the ore masses, the strike ranging from N. 34° E. to N. 59° E., though mostly about N. 54° E. The dip is nearly vertical, in some places southwesterly.

In order to obtain for the purposes of this report some idea of the length of the deposit a workman, furnished by Whitney & Lass, made several small excavations along a cross section about 100 feet to the southwest. Four of these reached bedrock, and in all of them ore similar to that at the main exposure was found. The extreme width of the ore indicated by these pits was about 45 feet, but neither wall was uncovered.

Along a cross section some 75 feet farther to the southwest he dug two pits 8 feet apart to bedrock. Both showed ore judged to be like other ore, of which the field estimate was 15 per cent of chromic oxide and the laboratory determination 28.62 per cent. Owing to the soil covering and the irregularity of the bedding it is impossible to decide whether this poorer ore indicates decreasing chromite content

along the strike or is simply, as is so frequently observed elsewhere, a leaner band interbedded with better ore. To the northeast of the main exposure the chromite was found at a distance of 25 feet, though only slightly exposed. The total length is thus at least 200 feet, probably more, and the width may be placed tentatively at 30 feet.

**11.** Along the rocky shore where the low-lying west end of Claim Point hill is exposed to the open ocean there are many stringers of chromite in more or less detached exposures for an extreme distance of some 500 feet. At the westernmost exposure their strike is S. 86° E., which would carry them, if they continue on this course under the covering of vegetation, very near to deposit No. 10, 1,500 feet to the east. Their dip is 60° or 70° S. They are mostly below high-tide level. The ore is variable in quality, including several lenticular bands of high-grade chromite 2 to 6 inches thick and 4 to 8 feet long. At three or four points a thickness of 4 feet of fair concentrating ore is reached. The variation in quality along the strike is so great that no valuable estimate of the amount of ore rich enough for concentration can be made, as no length can be assigned to the workable portions. It can only be stated that doubtless a considerable amount could be procured above low tide, and very likely a larger quantity at greater depth.

**12.** About 600 feet southeast of the east end of the last-mentioned series of deposits, also along the shore, is a set of chromite bands striking N. 52° E. and dipping almost vertically. The chromiferous zone is about 30 feet wide, with indefinite boundaries. Single layers of clean chromite reach about an inch in thickness. Some of these can be traced continuously for 10 to 15 feet. Of this material 28 inches, in five or six bands two of which were about 8 inches thick, was estimated to be half chromite. Perhaps 10 feet or even more might prove to be of concentrating grade. At 50 feet to the east is another exposure of similar ore about half as wide. It is thought to be a portion of the same bands, offset, as usual, to the right as the outcrop is followed.

**13.** On the beach at the base of the cliffs northeast of Claim Point hill is a considerable amount of chromiferous sand which has been much concentrated by wave action, though still containing a large percentage of what appears to be olivine. Whether this is rich enough for direct shipment or should be further concentrated had not been determined at last reports, though it seems highly probable that with a mill in operation removal of more of the waste would be found desirable. The sand has evidently been derived from the friable rock by wave action. Its quantity is small, compared with the deposits which occur in place, yet it and other occurrences of similar character that may be hereafter found are worthy of consideration.

**14.** A deposit of chromite of no considerable economic importance is situated in the brecciated zone near the dunite boundary about half a mile north of Claim Point hill, across the small bay from the wharf. It occurs as a chromite breccia in several separated masses, the largest some 6 feet in diameter, composed chiefly of angular fragments that appear to have been broken from larger deposits, perhaps by magmatic pulsation. Some of the interstitial spaces between the brecciated fragments are empty; others are filled with original silicate material or with what looks like a talcose alteration product. It is possible that the open spaces have been caused by removal of the carbonated or otherwise altered silicate constituent.

So far as their evidence goes, these deposits may indicate that large continuous bodies of chromite are not to be expected in the brecciated outer zone of the dunite, the originally large bodies having been completely broken into detached masses.

### QUALITY OF ORE.

No thorough study has been made of the nature of the chromite constituent of the Port Chatham ores nor of the mineralogic nature of their impurities. For the season of 1917 Lass[1] reports 46 to 49 per cent of chromic oxide in the output of the Reef mine. The product for 1918 was selected to approximate 40 per cent, for the contract conditions made such selection preferable to marketing only the richest ore, as had been previously done. The percentage of chromic oxide in the bulk ore has hitherto been the main factor considered in determining quality. For purposes of checking field estimates and judging the significance of specific gravity in determining the quality of these ores, three determinations were made on the Port Chatham material by Chase Palmer in the chemical laboratory of the United States Geological Survey, with the following results:

| | Per cent of $Cr_2O_3$. |
|---|---|
| Deposit No. 6, specific gravity 4.4 | 46.84 |
| (Reef mine) deposit No. 1, specific gravity 3.79 | 34.67 |
| Deposit No. 10, specific gravity 3.58 | 28.62 |

### TONNAGE.

The amount of ore present is computed on the assumption employed by J. B. Mertie, jr., in his preliminary study of the region, that extension in depth was originally substantially equal to horizontal length, and that the agencies of erosion which have exposed the deposits have, in that process, removed on an average half of each ore body. With cumulative evidence that the horizontal extent is greater than is shown by the exposures, either on account of faulting or covering by débris or both, it is difficult to make conservative estimates as to depth. Assumptions as to continuity have been dis-

[1] Lass, W. P., Min. and Sci. Press, No. 3, 1917, p. 653.

cussed in the descriptions of the individual deposits. Deposits that are calculated as containing less than 100 tons of ore are not included in the summation, for the probable error in the larger numbers is much greater than this amount. An attempt is made to discriminate roughly between shipping ore, placed at 40 per cent or more of chromic oxide, and concentrating ore, which is arbitrarily defined to include that which runs 10 to 40 per cent. Field estimates of quality, in which the judgment of those who have worked with these ores was kindly offered and freely used, are made the basis of calculation. The estimated percentages of chromite have been found to check reasonably well with the specific-gravity determinations, though it should perhaps be stated that chemical analyses, of which six were made, give an unexpectedly high content in chromic oxide for the lean ores and a lower amount than was foreseen for the richer specimens. These facts can be explained only by further investigation.

In the following table the ore bodies are designated by the numbers employed in the detailed descriptions:

*Estimated quantity of chromite ore at Port Chatham as calculated from the observed dimensions, in tons.*

| No. | Shipping ore. | | Concentrating ore. | | Chromite in concentrating ore. | |
|---|---|---|---|---|---|---|
| | Above tide level. | Below tide level. | Above tide level. | Below tide level. | Above tide level. | Below tide level. |
| 1 | 1,300 | 10,000 | 550 | 4,800 | 300 | 2,500 |
| 3, 4 | | | 1,000 | | 350 | |
| 5 | | | 300 | | 100 | |
| 7 | | | 2,300 | | 750 | |
| 8 | | | 20,000 | | 6,000 | |
| 10 | 10,000 | | 60,000 | | 24,000 | |
| 11 | | | | 6,000? | | 1,200 |
| 12 | | | | 1,000? | | 200 |
| | 11,300 | 10,000 | 84,150 | 11,800 | 31,500 | 3,900 |

Disregarding the concentrating ore in its crude condition and assuming a recovery of two-thirds in the concentrating process, we find that the final estimates of exportable ore would be, above tide level, 32,300 tons; below tide level, 12,600 tons.

## MINING AND SHIPMENT.

At Port Chatham the mining operations have been conducted by open-cut workings, chiefly at the Reef mine. Great inconvenience has been experienced from the tides, as a large part of the output has been taken between high and low water. Any considerable additional production from this deposit will necessitate an entire change of method, as the portion of ore above low water has been

largely removed. It is therefore probable that the next deposit to be exploited will be that numbered 10 in the list of descriptions. At this deposit relatively light stripping will uncover a large body of ore on the hillside in favorable position for removal. Open-cut methods will reach a large tonnage and may be found practicable to a considerable depth, for the width of the deposit is 30 to 50 feet, and the walls are of solid rock.

Operations on deposits numbered 2, 5, 7, 8, 9, 10, 13, and 14 have been as yet of rather exploratory character, though a little ore from several of these deposits has been shipped.

Facilities for shipping the Port Chatham ore have been much improved during the season of 1918. A new wharf has been constructed in the bay north of Claim Point hill, and it is reported that with the cooperation of the United States Coast and Geodetic Survey a wire drag of the harbor was carried out.

## RED MOUNTAIN.

### DEPOSITS.

In the Red Mountain area not less than 23 deposits capable of furnishing chrome ore when transportation conditions are favorable were observed in place. In addition to these, at least 10 occurrences of good ore in loose blocks were noted. Some of these float indications bespeak heavy deposits; others may have been derived from bodies too small or too much crushed to be workable. The abundant and rich-looking chromite fragments east of the main head of Windy River have very likely been in large measure brought by glaciers from the great mass to the southeast, on which the Star Chrome No. 4 claim is located. As a rule, however, the loose material is judged either to be without much doubt derived from ore bodies not seen in place, or, if from any of the ore bodies that were seen, to be so located as to indicate an immensely greater extension of those bodies than was assumed in the quantity estimates.

The number of mining claims located in this district is, as nearly as could be ascertained, 49, of which 14 are held by Whitney & Lass, 19 by F. P. Skeen, 10 by Babcock & Martin, 3 by Cramer & Martin, and 3 by R. V. Anderson. According to common report, all other claims made at earlier dates have been abandoned.

The ore bodies observed in place at Red Mountain occur as a rule in the firm jointed dunite and not in the crushed and hydrated outer zone. The single exception is deposit No. 22, which is in the peripheral material. Hence the location of the larger ore masses is chiefly on the inner or outer walls of the horseshoe ridge. The fact that most of them were found at somewhat high altitudes seems due

rather to the débris covering of the lower slopes than to a less abundant supply of chromite in the lower rocks. If any portion of the area is really devoid of workable chromite it would seem to be the southeast slope and cliffs of the spur between the upper drainage basins of Fish Creek and the northerly fork of Seldovia River.

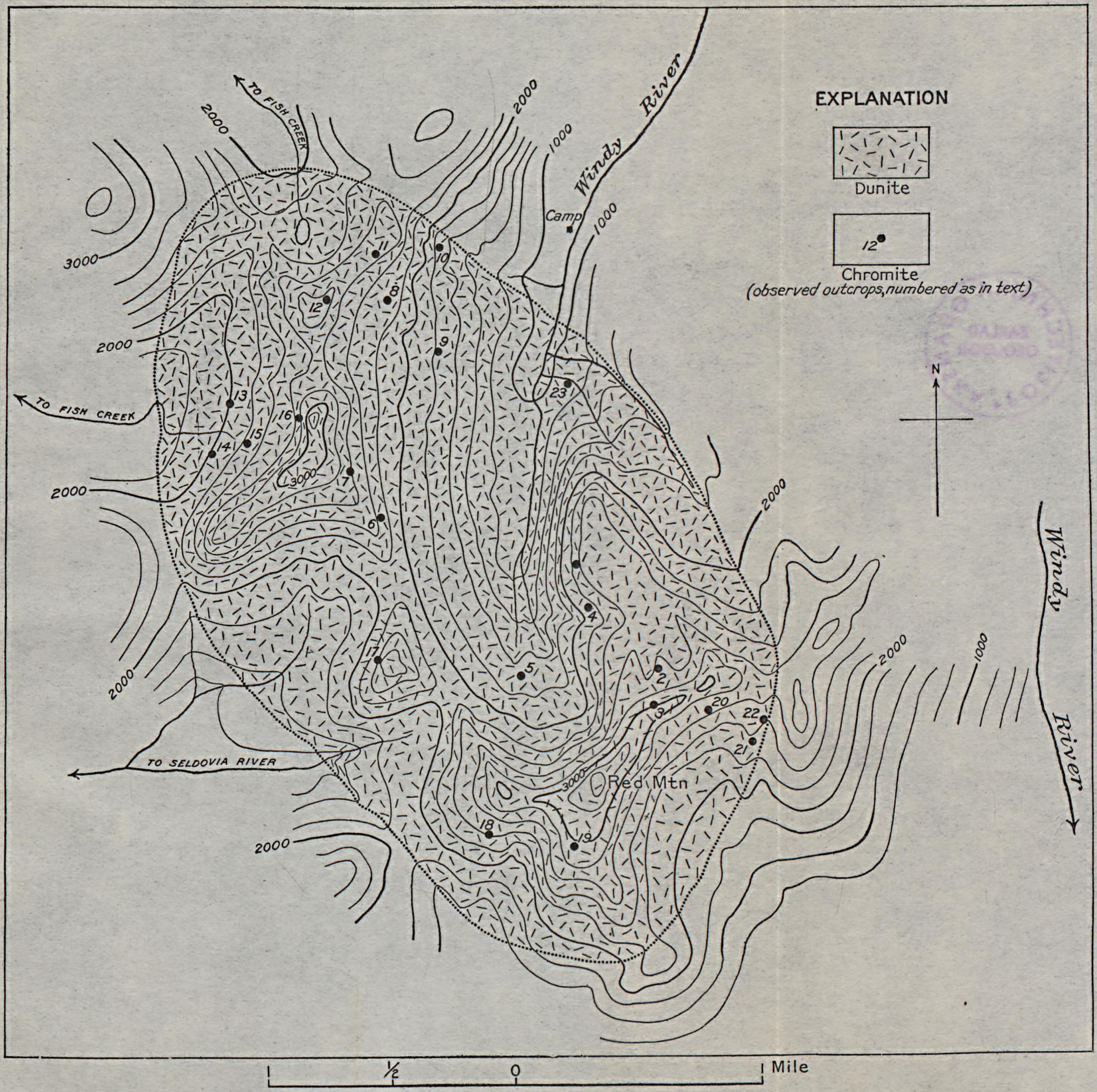
The ore bodies in the Red Mountain district seem on the whole longer and thinner than those at Port Chatham, less markedly banded but nevertheless of striking similarity in character. Descriptions of the salient features of the separate deposits will be given in the sequence of their location, following first around the inner basin at the head of Windy River and then around the outer slopes of the main ridge. The positions of these deposits are shown on Plate III.

**1.** At the northwest end of the high ridge that divides the main valley at the head of Windy River from the valley of its small tributary that flows along the dunite contact and parallels this ridge to the north is a chromite deposit on one of the Babcock & Martin claims.

Its altitude is about 2,300 feet, and the descent to Windy River to the northwest is precipitous. This occurrence is unique in that it is composed of two parts which appear to be of different origin. The heaviest part is an irregular mass of lustrous black chromite with cleavable green hornblende at both contacts and at some points in its interior. It has the strike usual in the chromite bands of this vicinity, about N. 10° W., but its dip is at a low angle to the east, instead of about 45° W., which is the prevailing dip. A sample was found to have a specific gravity of 4.46, with only 32.10 per cent of chromic oxide. (See p. 122.) This occurrence was noted in the field as probably recrystallized, and its variation in composition from the usual type was expected.

The part of this exposure that conforms to the usual type is more uniform in thickness, reaching a maximum of a little more than 2 feet. It seems to be cut by the recrystallized vein, a part of the outcrop occurring at their intersection. From its bearing on ore genesis this deposit would deserve much more careful study. As a source of chromite, in view of the low tenor of the recrystallized ore, it is probably of minor importance, as its thickness decreases to about a foot within 40 or 50 feet.

**2.** The exposure of ore body No. 2 is by far the most extensive seen in the district. It is covered mainly by the mining claims located by F. A. Rapp for Whitney & Lass, known as Star Chrome No. 4. It is at an altitude of about 2,600 feet on a sort of ridge-ribbed plateau in the easterly angle of the main valley. It strikes N. 8° W. and dips 60°–70° W. A section at the discovery monument was measured as follows:




Contour interval approximately 200 feet

MAP SHOWING CHROMITE DEPOSITS AT RED MOUNTAIN.

*Section on Star Chrome No. 4 claim at discovery monument.*

| | Ft. | in. |
|---|---|---|
| Dark ore, mostly of shipping grade, containing 16 inches of silicate rock in five bands, the thickest of which is 6 inches | 10 | 7 |
| Rock | 1 | 2 |
| Black ore | | 4 |
| Rock | | 5 |
| Ore | | 5 |
| | 12 | 11 |

For 500 feet along the strike northward from the discovery monument the ore is in a trench or gully, doubtless excavated by glacial action on the less resistant chromite. Exposures are frequent enough, in spite of the loose material, to leave no doubt of the continuity of the ore for the whole distance, probably with only gradual variations in cross section. At 500 feet from the monument the section was as follows:

*Section on Star Chrome No. 4 claim north of discovery monument.*

| | Ft. | in. |
|---|---|---|
| 20 per cent ore | 1 | 10 |
| Mostly dunite | | 10 |
| 10 per cent ore | | 8 |
| 40 per cent ore | 1 | 5 |
| Rock | | 6 |
| 42 per cent ore | | 11 |
| Rock | 2 | 2 |
| 50 per cent ore | 1 | 2 |
| | 9 | 6 |

For the next 200 feet northward on the ore the stringers get farther apart, but one rich band maintains a thickness of 6 to 14 inches for a distance of not less than 500 feet.

South of the discovery monument the chromite can be traced for 130 feet, to a point where it is reduced to a thickness of 18 inches of good ore. At about 50 feet from the monument there is an offset of 10 feet to the right, showing that faulting has occurred in this region.

Estimates of quality are based on the appearance of the ore. They seem to be corroborated by the specific gravity of 4.16 to 4.25 found for the richest specimens. The relative proportion of shipping ore here is judged to be unusually high. It may conservatively be placed at half the volume of the ore body.

**3.** At an altitude of about 2,950 feet, on the inner wall of the main valley, about 200 feet below the summit of the ridge, above the upper limit of the talus and nearly south from deposit No. 2, are many chromite stringers striking N. 30° W. and dipping 40° W. Two

higher-grade ore bands reach a thickness of 2 feet each. The low-grade material is mostly too poor to be considered workable. At the top of the ridge the ore was estimated by F. A. Rapp, who made the difficult ascent, to have a total thickness of 10 feet, of which 18 inches seemed to be of shipping grade, while the remainder was rated at 20 per cent chromic oxide.

4. West of north from deposit No. 3, at many points on the rough surface of the westward-tilting "plateau," are stringers of both high and low grade chromite which seem too small for separate mention, as a rule, though four lenses south and west from deposit No. 1 were noted as of shipping grade, with dimensions of 12 to 15 inches in greatest thickness and 10 to 20 feet in length. The dip and strike of the ore bodies in this region are in general somewhat parallel to the mountain slope, so that in many places a 1 or 2 inch layer of chromite simulates in appearance a heavy lens of ore through its exposure as a thin layer on a surface 2 or 3 by 8 or 10 feet. Of the lower-grade bands observed in this region only one seemed of sufficient importance for description. It is exposed for 100 yards or more along the south wall of the stream which drains this so-called plateau area, at altitudes of about 2,000 to 2,200 feet. Its continuity for the whole distance along the wall is probable, though it was seen over perhaps only half of the distance on account of the roughness of the surface and the necessity of passing close under the cliffs along the top of the talus slope, thus obscuring the view of the ore, if, as is thought probable, it was exposed. The thickness of this layer is somewhat more than a foot. It is faulted at several places, with displacements of a few inches to 3 feet. The grade of this ore is estimated at 15 per cent chromic oxide.

5. At an altitude of about 1,700 feet on the rocky spur that separates the main stream valley heading against the north slope of Red Mountain from the small brook that heads near the easterly pass to the Seldovia River drainage basin is a body of chromite on which the Horseshoe claim of Whitney & Lass is located. It is exposed for about 60 feet with a thickness of 1 to 3 feet. Fully half of it appears to be of shipping grade. It shows several small faults, one with a throw of about 3 feet, and ends so abruptly as to suggest faulting as the cause of its termination. To the north, diagonally downhill, are many small chromite stringers in the rocky stream beds for a distance of 300 or 400 yards. The largest of these, composed of low-grade ore, has a thickness of about 2 feet and is much contorted. This occurrence, which is at an altitude of about 1,400 feet, is accompanied by a crushed zone, so that there is much doubt whether it is a faulted continuation of the Horseshoe ore body or not. On the whole it seems more probable that it and the many intervening layers are in a position underlying the Horseshoe. The

lower ore bands strike about N. 20° W. and dip 75° SW. Above the crushed zone the dips are much flatter, as a rule, though very variable.

**6.** The rich but small ore lenses that occur near the two low divides to the Seldovia River basin lie in nearly horizontal position. The next deposit of sufficient importance to be mentioned is that on the Star Chrome No. 2 claim of Whitney & Lass, at an altitude of 2,300 feet on the northeast slope of the main ridge northwest of the western pass toward Seldovia. Good ore is exposed for a distance of 50 feet with a thickness of 14 to 24 inches. About 200 feet to the southeast is a 12-inch exposure of good ore which seems to be connected by low-grade stringers with the main mass. The ore here lies nearly horizontal.

**7.** At an altitude of nearly 2,500 feet on the same ridge with deposit No. 6 and in line toward the high dunite point on the west ridge is an exposure of 12 to 15 inches of good (40 per cent) ore with a foot of rocky material on each side of it which was judged to carry only 5 to 10 per cent of chromic oxide. Uphill this runs down to only 6 inches of good ore within a distance of 10 feet. If it continues to widen downward under the talus slope at this rate it may be a considerable ore body. The strike is N. 22° W. and the dip about 45° SW.

**8.** On the shelf or narrow plateau, which is seemingly a remnant of the old valley floor not removed by the glacier which deepened the center at an altitude of a little more than 2,200 feet and about half a mile south of the lowest pass to Fish Creek, is the deposit on which the Juneau No. 1 claim is located. Its strike is N. 58° W. and its dip 45° SW. At the southeast end of the natural exposure the cross section consists of 18 inches grading regularly from rock to shipping ore, 82 inches of good ore, and 12 inches showing gradation back to wall rock. About 100 feet southeast of this point a pit dug through about 3 feet of surface material uncovered the chromite with a width of 5 feet of banded and disseminated ore, half of which is estimated at 30 per cent chromic oxide, and the rest of poorer grade. The covering of the ore contained little or no chromite, indicating that it is not a result of weathering in place but was brought from less chromiferous localities by glacial action or hill creep. At 50 feet northwest of the heavy outcrop mentioned above the ore attains its maximum thickness of 12 feet, and at 30 feet farther in the same direction it comes to a sudden end. This is probably at a fault, as there are several small step faults in the 80 feet of exposure. Until the discovery of deposit No. 2, in July, 1918, this was considered the best body of chromite in the district.

**9.** The series of chromite layers described together under No. 9 would probably be classed as at least three separate deposits, and very likely more than that, if time had been available for carefully

working out all details observable in the exposures, which are located in the irregular cliffs southeastward from deposit No. 8 at altitudes of 1,200 to 1,800 feet. None of them presented a thickness of more than 3 feet of concentrating ore or 16 inches of high-grade ore in a single band. Such bands are locally within a foot or two of each other, however, so that if one were worked the other would doubtless also be taken.

The highest exposure, at 1,800 feet, consists of two bands with a total thickness of 4 or 5 feet of concentrating ore. They strike N. 20°–25° W. and have a westerly dip.

About 150 feet lower on the mountain side is a set of chromite stringers in a section of 25 feet, two layers in which attain a thickness of 1 foot each. This series of bands can be traced for a distance of at least 250 feet, up to an altitude of 1,900 feet, at which they pass to inaccessible cliffs where they can be seen for perhaps a hundred yards farther. They appear to pass under the Juneau No. 1 lode and are separated from it by a heavy pyroxenite band, which, like many smaller ones observed in this locality, is parallel to the ore stringers. They strike N. 6° W. and dip 45° W.

At altitudes of 1,200 to 1,400 feet near the base of the cliffs is a series of small high-grade chromite bands, approximately in parallel position under those just mentioned. The largest of these maintains a thickness of 8 to 16 inches for a distance of not less than 300 feet. How many of the associated smaller bands would pay for working is uncertain, but without question many of them would be utilized if the larger mass were mined.

**10.** The Juneau No. 4 mining claim of Whitney & Lass is at an altitude of 1,600 feet, 100 yards or so southwest of the small stream that heads against the Fish Creek basin at the dunite contact. The ore body is so near the contact that it is within the crushed zone, though not so completely broken up as the silicate rock nearer the boundary. Its thickness is somewhat variable, mostly 3 to 4½ feet, though at one point it pinches down to about a foot. Its length is not less than 250 feet. It ends abruptly at the top, doubtless at a fault, with a thickness of 2 feet exposed, while the north wall is obscured by débris, so that only this minimum thickness could be determined. At the lower end it passes under talus in which there are many chromite fragments for 100 feet or more. These may have fallen from the exposed portion. The chromite body strikes N. 82° E. and is practically vertical in dip. It seems to be largely of excellent quality, though its crushed condition renders its appearance somewhat abnormal.

**11.** A quarter of a mile south of the lowest pass between Windy River and Fish Creek is a heavy chromite band that apparently crosses the main ridge, which is here double for a considerable dis-

tance, the two parallel crests being some 150 feet apart. At the easterly crest excavation by F. A. Rapp in the crumbly chromiferous loose material uncovered the ore at a depth of about a foot with a cross section, beginning at the north, as follows: 30 inches nearly half chromite; 48 inches mostly rock; 84 inches good ore, of which at least two-thirds is of shipping grade. A hundred feet away down the mountain side to the east the ore has an easterly strike and nearly vertical southerly dip. Its section at this point shows 18 inches of shipping ore and 78 inches estimated at half chromite. About 20 feet higher this section revealed 72 inches of ore, at least half of it estimated to run 40 per cent chromic oxide or better. This deposit may have been originally a part of No. 9, above described, but the intervening terrain is with difficulty accessible, even where not covered with talus, and the relation was not proved.

Toward the west chromiferous float can be traced continuously to the top of the west ridge, whence a low grade band perhaps 3 or 4 feet in thickness can be seen in the vertical rock wall with a moderate dip—about 45°—to the south.

**12.** From deposit No. 11 the main dunite ridge runs due southwest for 500 or 600 yards to a culminating point which appears by aneroid determination to be almost exactly 3,000 feet above the sea. About 100 yards northeast of this summit three bands of chromite appear from blocks and fragments not exactly in place to cross the crest of the ridge. They are 50 to 75 feet apart and appear to have a thickness of 2½, 5, and 2 feet, respectively. The larger one is thought to continue along the westerly slope of the ridge and to be identical with an ore body located by N. Clarberg for Whitney & Lass. He described it as on the back side of this mountain, and one of his monuments was seen at an altitude of 2,700 feet on the spur that runs from this peak and divides the two main heads of Fish Creek. The fog was so thick at the time of the writer's visit, however, that this identification could not be confirmed. The deposit is said to be 3 or 4 feet thick, mostly of rather low grade, and to dip south.

**13** and **14.** Deposits Nos. 13 and 14 are probably either parts of the same ore band or different bands in a closely related series. Both nearly follow the 2,000-foot level at the southerly head of Fish Creek, strike about N. 20° E., and dip at a variable angle, mostly much less than 45°, to the east. No. 13 is north of the main stream and can be followed along the mountain side for a distance of fully 500 feet. It is broken at many points by small faults. Its thickness ranges from 1 to 2½ feet of fair concentrating ore, with only a little that appears to be as rich as 40 per cent chromic oxide. Toward the north end there are three bands of chromite, each more than a foot thick in a section of 100 feet, one of which is probably

the continuation of this layer, though this continuity is established only by the occurrence of chromite of similar rather low grade in the blocks fallen from the cliffs. Still farther, about 500 yards south of the 2,100-foot divide, between the heads of Fish Creek, a portion of one of these ore bands shows 6 inches of nearly shipping grade underlain by 5 or 6 feet of poor disseminated ore. At this point the strike is N. 51° E. and the dip 55° SE. No. 14 can be followed for more than 400 feet, beginning near the main stream and following approximately the top of the talus slope toward the divide between Fish Creek and a branch of Seldovia River. Its thickness is nowhere less than a foot and in some places reaches 2½ feet. Most of it is only of concentrating grade, though in many places there is some high-grade material, at one point reaching a foot in thickness. The dip of the ore becomes flatter toward the south.

**15.** In the upper cirque at the head of the south branch of Fish Creek at an altitude of about 2,350 feet, southeast of the stream, is a band of chromite from 12 to 24 inches thick, which is estimated to carry 35 per cent chromic oxide. Toward the southwest it is cut off by a fault. About 50 yards distant and 30 feet higher than this faulted end are some low to medium grade stringers which are judged to be the continuation of the same ore body. To the northeast it passes under the talus with a thickness of 2 feet and with seemingly increasing magnitude. The main exposure is some 50 or 60 feet in length.

**16.** High in the wall of the cirque, about northeast of deposit No. 15, is a black mass that looks at a distance like very rich chromite. This appearance seems to be confirmed by the presence of high-grade float in large blocks at the foot of the inaccessible cliffs. The suggestion that this deposit may be a continuation of No. 15 is rendered plausible by the increasing dips of the chromite bands in that direction. The presence of a heavy pyroxenite band below raises the further question whether it may not also be a part of the ore stringer on which Juneau No. 1 claim is located (deposit No. 8), as that also seems to be underlain by a similar pyroxenite layer.

**17.** In the pyramidal peak between the two low passes from the head of Windy River to the Seldovia River drainage basin there is at least one chromite body of considerable magnitude. It is covered by a mining claim of F. P. Skeen. It is not well exposed on the north side of the mountain, though its nearly horizontal position and the presence of considerable chromite float, part of it very rich in appearance, would indicate its probable extension to that slope. On the northwest declivity, however, at an altitude of about 2,400 feet and just above the talus slope, it shows for a distance of some 350 feet. At its northern extremity it is cut off by a fault of unknown

but probably not great magnitude. For 60 feet it maintains an average thickness of 4 feet, then gradually frays out into a series of separated lenses to the south. There are several small faults, of which the largest has a displacement of about 6 feet, showing relative raising of the southerly block.

The ore contains some high-grade lenses but is chiefly of good concentrating type. Below this ore there is much more chromite in the talus blocks down to the 2,000-foot level than would seem likely to have been derived from a single layer of this magnitude, but no other was seen in place.

**18.** At an altitude of 2,400 feet on the southerly spur of the high point half a mile west of Red Mountain is a chromite body which strikes N. 24° W. and dips 35° SW. At its upper end, where it shows about 4 feet of fair concentrating ore, it is cut off by a fault. Downward it passes under the talus but reappears at a distance of some 120 feet with a cross section of 12 inches of rather rich concentrating ore, 30 inches of rock, and 20 inches or more (the lower wall is not exposed) of rich concentrating ore. Float at lower altitudes would indicate that the ore body continues down the spur with good quality and in considerable size.

**19.** On the spur running nearly south from the summit of Red Mountain, at an altitude of about 3,000 feet, is considerable low-grade chromite débris, indicating the locality where a very large ore body crosses the spur. The crest of the spur is marked by monuments as the dividing line between claims of F. P. Skeen and Babcock & Martin, Skeen and Babcock having made the discovery in common. The ore was not observed in place, as was expected, on account of the lateness of the hour when it was reached, though it had previously been seen from a distance near the top of the cliffs that constitute the flanks of the spur. Mr. Skeen states that it is the largest body of chrome ore seen by him at Red Mountain, the next largest being deposit No. 3.

**20.** At an elevation of about 2,600 feet on the southeasterly slope of the rugged ridge that runs northeastward from Red Mountain, just at the top of the talus and approximately a third of a mile from the pass (on the dunite contact) between the upper and lower portions of the Windy River valley, is a body of banded chromite. Its thickness is 3 feet where it passes beneath the talus, and it can be seen to maintain a thickness of approximately 2 feet for 200 feet or more up the steep cliffs. It strikes almost exactly north and dips about 70° W. Near its lower end is an offset to the right of nearly 20 feet, and in the higher portion three or more faults of somewhat less magnitude can be seen. The ore was judged in the field to be better than half chromite. A sample taken to show its average quality was found to have a specific gravity varying from 3.73 to 3.87.

**21.** On the ridge that runs S. 16° W. from the pass just mentioned, at an altitude of a little more than 2,300 feet, are three small chromite deposits, covered by a mining claim of F. P. Skeen. The largest of these shows a thickness of 2 feet of ore that runs about 30 per cent chromic oxide for a distance of 8 feet. The smaller deposits, just above this one, are of better grade but have thickness of only about a foot. All three are apparently terminated by faults.

**22.** In the bed of the small stream that flows near the dunite contact 100 yards or so northeast of deposit No. 21, at an altitude of about 2,460 feet, is a mass of chromite which lies within the outer crushed zone of the dunite. It is much slickensided and shows a thickness of 2 to 4 feet for about 30 feet. The ore is of good quality, but its crushed condition renders comparison with the ordinary ores of doubtful value. The character and distribution of loose material suggest that the ore continues for some distance, perhaps 100 feet, downstream from its lowest outcrop.

**23.** At an altitude of 1,100 feet in a shallow gully near the smaller (southerly) of two streams that flow northwestward into Windy River through the valley caused by erosion of the softer rocks at the dunite contact are large blocks containing at least 7 or 8 tons of excellent chrome ore. In one block the cross section showed 16 inches of 40 per cent to 50 per cent ore, 5 inches of waste, and 7 inches of ore of the same grade as the thicker layer. About 100 feet to the northeast in the stream bed are three 1-foot stringers of low-grade chromite striking N. 22° W. and dipping about 60° SW. Whether the blocks were derived from the same ore body that appears in the outcrop is doubtful, but they are certainly near the same position and indicate either an improvement in the quality of the ore along the strike or the presence of a second deposit of some importance.

Streams, glaciers, and frost have moved loose rock fragments so widely that it is doubtful if an acre of fragmental rock in the Red Mountain dunite area could be found without macroscopic chromite stringers at the surface. Yet there are many places where unusual accumulations leave no doubt that a workable chromite ore body is near at hand. There are also localities where rich fragments occur in such a manner as to show that good ore extends for a considerable distance without evidence that its thickness is sufficient to render it workable. Some of the most promising of these are occurrences described below.

From a point just south of the pass between Windy River and Fish Creek down the steep talus slope toward Windy River there are numerous flat chromite fragments, mostly under 3 inches in length. They extend for at least 200 feet. The best of the ore is mottled and has the composition shown in analysis No. 6, page 122.

A hundred feet below this pass, on the Fish Creek side, occur some scattered blocks and fragments of high-grade, much slickensided chromite in the soft-weathering contact zone. These continue for a distance of more than 300 yards downward, varying in abundance and reaching about a foot in maximum size.

On the ridge between the two heads of Fish Creek, about 150 yards west of its lowest point, is much brownish porous-looking chromite (analysis No. 5, p. 122) in blocks up to a foot or more in size. The small fragments extend down both slopes of the ridge for 200 or 300 feet. Their abundance indicates a very large ore body, though a little digging in the soft chloritic contact rock failed to locate it. On the same ridge, less than a hundred yards S. 25° E. from the low pass, are many small ore fragments indicating a fair-sized ore body of excellent quality. The fragments continue less abundantly and of poorer grade upward along the ridge to the southeast for 200 or 300 yards farther.

Large blocks of high-grade ore occur in the moraine at an altitude of some 2,000 feet just north of the main southerly branch of Fish Creek. These may have come from deposit No. 16, seen in the cirque higher up, but are so abundant as to suggest a much nearer source, as they would probably have become more scattered in traveling so far on the ice.

In the pass between Fish Creek and the Seldovia River basin on the dunite contact at an altitude of 2,100 feet there are a good many rich-looking chromite fragments as much as 6 inches in diameter. They extend some distance downward along the contact on the Seldovia River side, but if present on the slope to Fish Creek they are covered by a large snow bank and talus from above. Similar occurrences were observed at the dunite contact at several points southwest and south of Red Mountain.

Near the discovery monument of F. P. Skeen's Big Chrome No. 1 claim, at an altitude of 1,500 feet in the contact valley which slopes northwestward to Windy River, are very abundant chromite fragments 2 or 3 inches in length and estimated to contain 30 to 45 per cent chromic oxide. These fragments doubtless mark a considerable ore body.

Only three occurrences of chromite float in the inner basin of the Red Mountain ridge will be mentioned, though many more of less extent were seen. Two of these are thought to be very probably derived from ore bodies in place, already described. They are both on the rough surfaced plateau on which deposits Nos. 1 and 2 are situated. One of them consists of widely scattered high-grade blocks from a few pounds to half a ton in weight, some lying on bare dunite and some piled with other detritus, seemingly carried northward from deposit No. 2 by glacial action. Many tons of excellent ore could

be gathered from the surface. The other one occurs at the southwest edge of the plateau along its southerly half and consists of immense blocks of dunite, in which are many stringers of banded chromite. One block, 25 or more feet long, perhaps from deposit No. 3, was cut by a 3-foot layer of concentrating ore estimated at 20 per cent chromic oxide. A mixture of high-grade and low-grade ore in abundant blocks occurs at an altitude of 1,600 to 1,700 feet on the slope N. 51° E. from the pyramidal mountain between the low passes toward Seldovia. The larger blocks show at least 6 feet of concentrating ore, and some of the smaller masses a foot of fair shipping ore.

The quality of the Red Mountain chromite has not been investigated with any degree of thoroughness, though much material has been collected upon which such a study might be based. Analyses made by Chase Palmer in the chemical laboratory of the United States Geological Survey at the writer's request were directed to the determination of $Cr_2O_3$ in the aberrant varieties, as the great similarity to the Port Chatham material, combined with the high percentage reported by Grant[1] on a chromite from this area (the exact locality is not stated), leaves no room for doubt as to the general quality of the ore. Mr. Palmer's results, together with field estimates on the same specimens, are as follows:

*Analyses of chromite ore from Red Mountain.*

| No. | | Specific gravity. | $Cr_2O_3$ (per cent). Found. | $Cr_2O_3$ (per cent). Estimated. |
|---|---|---|---|---|
| 4 | Recrystallized chromite | 4.46 | 32.10 | 60 |
| 5 | Porous ore | 3.93 | 48.89 | 50 |
| 6 | Mottled ore (porous) | 3.59 | 41.93 | 30 |

Of these specimens No. 4 does not appear to contain any foreign material. It is from the recrystallized part of deposit No. 1. It shows a great divergence from the magmatic ores in chromic oxide content and its slight attraction by the magnet would suggest a high percentage of iron. Analysis No. 5 was made on material from the pass between the heads of Fish Creek, and No. 6 on a specimen from the main ridge at a point 100 yards south of the lowest divide between Windy River and the north branch of Fish Creek. These two analyses indicate that the somewhat spongy texture is no indication of inferior ore. The porosity may be due to removal of some

[1] U. S. Geol. Survey Bull. 587, p. 238, 1915; 57 per cent $Cr_2O_3$ is given as the result obtained by C. E. Bogardus.

of the interstitial silicate. The impurity seems to be olivine in the mottled ore and is very likely the same mineral in the other porous specimens.

### TONNAGE.

Calculations of the amount of chromite in the Red Mountain deposits were made on the same basis as for those at Port Chatham (p. 110). This method of estimate assigns a very large tonnage to the deposit on Star No. 4 claim—in fact, so much larger than to any others in the region that some hesitation is felt about its accuracy. However, the excellent exposure of this deposit at the surface leaves no doubt as to its longitudinal extent, so that it would be quite as reasonable to infer that the longitudinal dimension of the other deposits has been underestimated on account of poor exposure or of faulting as to assume an overestimate of depth for the Star No. 4 ore body, merely on the basis of inequality in size. On the whole, the alternative of low estimates seems more probable, though the factor of uncertainty as to depth should never be lost sight of in considering the significance of these tonnage figures.

Exclusive of those masses which do not appear to contain more than 500 tons, because this amount is within the limit of probable error of the larger numbers, the following table brings together the detailed estimates for the larger deposits:

*Estimated quantity of chromite ore as calculated from the observed dimensions, in tons.*

| No. | Shipping ore. | Concentrating ore. | Chromite in concentrating ore. |
|---|---|---|---|
| 2 | 90,000 | 80,000 | 32,000 |
| 3 | 5,000 | 25,000 | 10,000 |
| 4 | ........ | 5,000 | 1,500 |
| 5 | 250 | 1,500 | 600 |
| 6 | 250 | 2,000 | 600 |
| 8 | 10,500 | 6,000 | 2,500 |
| 9 | 5,000? | ........ | 5,000? |
| 10 | 8,000 | 5,000 | 3,000 |
| 11 | 7,000 | 16,000 | 8,000 |
| 12 | ........ | 10,000? | 4,000? |
| 13 | ........ | 22,000 | 6,600 |
| 14 | 1,000 | 14,000 | 4,200 |
| 17 | 1,000 | 16,000 | 6,400 |
| 18 | ........ | 3,000 | 1,800 |
| 19 | (?) | 30,000? | 12,000 |
| 20 | ........ | 6,500 | 3,200 |
| | 128,000 | 242,000 | 101,400 |

Assuming, as before, a recovery of two-thirds of the chromite in the concentrating ores, we find that the estimate of total exportable ore in the Red Mountain district becomes 195,600 tons.

#### MINING AND SHIPMENT.

No mining operations other than exploratory work have been carried on at Red Mountain. Even the route of shipment has not yet been decided upon by the holders of chromite claims, though Whitney & Lass devoted a good deal of effort during the summer of 1918 to finding a feasible route for transportation of loose or readily accessible ore in case insistent demand should arise.

### CONCLUSIONS.

#### AMOUNT OF ORE.

The amount of ore above sea level at Port Chatham, on the assumption that material containing 10 per cent of chromic oxide can be profitably concentrated, has been estimated at 32,300 tons. Below sea level there may well be a much greater amount, as the lower deposits are as a rule richer and heavier than those at higher altitudes, which is in accord with the theory of settling in a molten magma. But even by the same process of calculation that was used for the ore above sea level, the exposures examined lead to an estimate of 12,600 tons below tide. The availability of ore below water level is extremely problematic on account of the great prevalence of jointing in the dunite. These joints are so open as to constitute a serious menace of mine flooding.

The amount of chromite in sight at Red Mountain is placed at 195,600 tons. This is a minimum figure, for no estimate was made of the quantity of ore in those deposits of indeterminable size whose existence is indicated by very rich float at eight or ten widely separated localities, nor has any account been taken of the large area covered by talus and morainal detritus, which presumably is as rich in chromite as the exposed areas. If this last presumption were made a basis for calculation it would at least double the estimate of chromite present, for more than half the dunite area is covered by loose rock.

It should perhaps be emphasized that one main feature of these deposits which lends uncertainty to the estimates of quantity is their tendency to divide, along their strike, into parallel bands, grading thus into immense low-grade masses in which the dimensions of workable material can not be defined. Such deposits are either excluded from the computations or are assigned only such size as is indicated by the relatively homogeneous portions.

#### METHODS OF MINING.

The unusual persistence or continuity of the Kenai Peninsula chromite bodies promises to render a deviation from the open-pit

method of working both feasible and ultimately necessary. Crosscutting at levels much below the outcrop may be found to save hoisting of the ore and to reduce the distance from mine mouth to shipping point. One obstacle to underground mining will doubtless be the occurrence of numerous faults, though some localities have suffered much less faulting than others. In planning mining operations it should be borne in mind that in those places where the strike of the faults nearly coincides with that of the ore bodies, as near the Star No. 4 prospect at Red Mountain, continuity in depth may be much less than along the surface, though extension in depth is to be expected when the continuation is located.

As an emergency procedure the gathering of scattered fragments of ore at the surface in the Red Mountain district might furnish several hundred tons. The sands at Claim Point and some stream gravels near Red Mountain suggest the further possibility of washing, though only on a relatively small scale.

### CONCENTRATING.

So long as chrome ore containing 40 or 45 per cent of chromic oxide is marketable, it will doubtless pay to continue the present process of hand sorting except for the few deposits that may be found to yield ore rich enough to ship as mined. But there will always be a by-product of low-grade ore which must be handled even if it is not utilized. There are also large masses composed chiefly of low-grade ore which would not repay the cost of exploitation if only the shipping ore were marketed. Much of this material, say that running above 10 per cent chromic oxide, will doubtless prove profitable to concentrate by washing. Concentration has been found feasible at several of the Canadian deposits, where, however, serpentine instead of olivine seems to be the chief impurity. At Claim Point a milling plant is being installed, after a series of tests conducted in one of the mills regularly operating on gold ore near Juneau. This milling project has been undertaken at Claim Point even with the necessity of pumping or of bringing water across the bay from the creek to the north. At Red Mountain the water supply is ample up to an altitude of 1,200 or 1,500 feet. On the whole it may be estimated that one-half to three-fourths of the available tonnage of chromite in this region would require concentration, and if it shall be found that ore carrying less than 10 per cent chromic oxide can be profitably milled, the tonnage of available chromite will be much greater than these estimates, though, of course, the percentage suitable for direct shipment would be less than suggested.

Experimental determination of the relative behavior of olivine, pyroxene, and serpentine under mill tests would be of much practical interest. In the light of present experience economic handling

of these deposits would seem to require the installation of concentrating machinery.

The spongy and friable ores will doubtless lend themselves readily to crushing, though the problem of slimes may prove troublesome, especially in ore from the shattered areas.

The recrystallized chromite and possibly some of the original mineral can not be brought by concentration to a high content of chromic oxide, for the chrome-bearing mineral, even when in a pure, unmixed state, is a low-grade ore.

## TRANSPORTATION TO TIDEWATER.

At Port Chatham the problem of reaching tidewater is simple. The new tramway promises to suffice for the large deposit on the northwest slope of Claim Point hill. For the higher deposits on the northerly side of the hill an extension of this tramway system may be found satisfactory, though the alternative procedure of tunneling from a point near tide level, entering the high sea wall at the northeast bight, is suggested by the possibility that the chromite stringers exposed in this cliff are continuous with those in the higher pits. At any rate the lower ores can be taken out in this way until they cease to repay working, when it may be possible to form a more definite opinion as to their connection with the upper deposits. All other known ore bodies at this locality are practically at sea level or below it.

At Red Mountain the transportation problem is much more difficult. In fact, it is a group of problems, for the chromite occurs at both high and low altitudes on the inside of the horseshoe ridge and also at many disconnected points on its outer slopes. It seems probable that concerted planning by all the holders of chromite properties in the region would be in the interest of ultimate economy, though only further development of the deposits combined with accurate surveys of the possible routes can furnish a really sound basis for a final decision as to outlet. Practical miners who have studied the situation seem to agree that the aerial tram promises to be the best means of making the initial descent from the higher ore bodies toward tidewater. It is possible here, however, as was suggested in the discussion of Claim Point, that if some of the lower deposits are worked first they may furnish underground access to those at greater altitudes. Though sufficient data may not be at hand for making final decision as to the best approach to water transportation, some of the features of the various routes may be compared.

Tutka Bay has excellent depth of water and is only 6 miles from the inner basin of the Red Mountain Ridge. The route to it would lead down the open valley of the northward-flowing portion of

Windy River for 2½ miles, then over a low divide estimated to be at an altitude of about 800 or 850 feet into a canyon-walled head of Jakolof Creek. Whether the east wall of this canyon would be as difficult as the west wall is more or less a matter of conjecture, but it appears to be easier as seen from below. The approach to Tutka Bay after reaching the low, flat land is also somewhat of a problem, as the natural opening through the ridge that follows the southwest shore of the bay is narrow and steep walled.

Jakolof Bay is at about the same distance from the dunite area as Tutka Bay. The upper part of the route to it would be identical with that of the Tutka Bay route except as facility in the lower course might indicate a different location higher up. The Jakolof roadstead is more rocky and shallow, however, which might necessitate a longer road to navigable water.

Fish Creek, entering Cook Inlet at Barabara Point, would lead to any depth of water that might be desired at the dock terminal. It touches the chromiferous rock at two places on the outside of the ridge. As seen from above, the valley of this stream looks passable for a road after the first steep descent over glacial débris has been accomplished. The distance is approximately 8 miles. This route would serve three or four good deposits of chromite but is cut off from the inner basin by a ridge more than 2,600 feet in altitude, except by the roundabout way of the headwaters of Seldovia River, where there are two passes at a height of less than 2,200 feet.

Seldovia Bay has the advantage of a well-charted harbor and a populated town. The route from this point to Red Mountain would reach dunite at an elevation of 1,200 to 1,400 feet above sea level. Its length would be 8 miles or more. The two passes to the inner basin are at an altitude of about 2,150 feet. The lower part of this route is said to be along a very steep rocky mountain side. Its upper end is over alternating flats of glacial boulders and rather steep rock or talus slopes.

Rocky Bay appears to be excluded from consideration by the extremely dangerous character of its harbor, coupled with the fact that Port Dick is equally accessible from the landward side and incomparably safer by water.

Port Dick has deep water within a mile of the head of the bay. The configuration of the bay is such that tidal currents are moderate for this region. The valley of Port Dick Creek leads to that of Windy River over a flat divide estimated at 100 feet above sea level. This estimate is based on an aneroid reading of 75 feet at the flat sphagnum meadow near the head of the creek, together with the observation that no dividing elevation was discernible from a height of 400 or 500 feet on the mountain slope north of the meadow. The

Port Dick route would reach the southeast end of the dunite area with a length of about 8 miles, having easy grades to the point where an aerial tram might set down ore from the two or three outer deposits which it would directly approach. Grades would be moderate also by way of the Windy River valley around to the inner basin, but the distance would be 7 or 8 miles more, and there is said to be a steep-walled narrow canyon with at least two waterfalls in the middle of this route.

The suggestion may finally be made that an ore road at an elevation of approximately 2,000 feet around the outer slopes of the dunite might connect all the peripheral ores with Barabara Point, Seldovia, or Port Dick, while connection with the inside might be made over one of the 2,150-foot passes to the Seldovia River valley or possibly by a tunnel on pay ore at any one of the several lower chromite bands. The northerly head of Fish Creek would seem most promising for the latter method of development if it were to be considered at all.

Investigations by Whitney & Lass into the possibility of an inexpensive wagon road for emergency shipment from the inner side of the horseshoe ridge, where the best of the known chrome deposits are situated, led to an adverse conclusion, on account of the steepness of the canyon walls and the occurrence of waterfalls both along the course of Windy River and along the small streams entering Jakolof Bay with low divides to the Windy River basin.

## SHIPMENT AND MARKETS.

Ocean freight rates will doubtless be a permanent factor in the Alaskan chromite production, as the lack of a local market is likely to continue indefinitely. With these rates as at present, $3.50 a ton to Seattle, it seems probable that the expense of delivering Kenai ore at Pacific coast points need not be greater than that for ore from many of the California and Oregon deposits.

The location of some of the Kenai deposits at or near tidewater, where the ore can be cheaply loaded into ocean-going vessels, gives them an advantage over the California deposits, most of which are in mountainous districts remote from the coast—an advantage that compensates in part, at least, for their greater distance from American markets. While it is still uncertain whether any chrome ore mined in the United States or Alaska can successfully compete in peace times with chrome ore from Rhodesia and New Caledonia, the outlook for the Kenai deposits appears to be at least as favorable as for those of California and Oregon.

## ACKNOWLEDGMENTS.

In concluding this report acknowledgment should be made of the extremely friendly and helpful attitude toward its preparation which has been taken by the owners of the chromite properties, as well as by several members of the United States Geological Survey in Washington and colleagues at Cornell University, Ithaca, N. Y. Especial aid has been rendered by Capt. G. H. Whitney, Mr. W. P. Lass, Mr. F. P. Skeen, and Mr. F. A. Rapp.

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# MINING DEVELOPMENTS IN THE MATANUSKA COAL FIELD.

By Theodore Chapin.

## INTRODUCTION.

The following report is based on several weeks' field work done at different times during the summer and fall of 1918 and includes developments up to the end of 1918.

The Matanuska coal fields are in the valley of Matanuska River, a tributary of Cook Inlet from the Talkeetna and Chugach mountains. This region has a special interest on account of the control and operation of two coal mines at Eska and Chickaloon which are being developed by the Department of the Interior through the Alaskan Engineering Commission.

The coal mines of the Matanuska Valley are from 50 to 75 miles from the town of Anchorage, which was established in 1915 as divisional headquarters for the railroad and as a shipping point and landing point for construction material. Anchorage was at first known as Ship Creek, the name of the stream on which it is built. It is on Knik Arm, a branch of Cook Inlet, and is opposite Knik Anchorage, the head of steam navigation for ocean-going steamers on Cook Inlet. Anchorage is the nearest point on the seacoast from which the Matanuska coal can be shipped, and is now connected by rail with the town of Seward. Under natural conditions Knik Arm is considered a closed port during four or five months of the year on account of the ice in the inlet. Engineers of the Alaskan Engineering Commission who have made a special study of ice conditions on Knik Arm believe, however, that these difficulties can be overcome and that terminal facilities and docks now under construction will make Anchorage an open port for ocean-going vessels for a larger part of the year.

The coal mines are served by the Matanuska branch, a spur of the Government railroad now under construction from Seward, on the Pacific seacoast, to the interior. The Matanuska branch leaves the main line at Matanuska, 37 miles from Anchorage. From Matanuska

it is 38 miles to Chickaloon, the terminus of the spur. Construction work on the road toward the mines was started at Anchorage in May, 1915. Steel was laid to Moose Creek in August, 1916, and was completed to Chickaloon in October of the following year.

The geology of the coal fields of the Matanuska Valley is best known from the writings of G. C. Martin, who first visited the region in 1905 and made a general reconnaissance. In 1910 and 1913 Mr. Martin and his associates made more detailed studies of the lower part[1] and the upper part,[2] respectively, of the Matanuska coal fields.

The work of 1910 is of the most interest in this connection, as it covered the region in which the productive mines are situated. In the report on this work the general geologic features of the lower Matanuska Valley are recorded, with as many details of the structure and stratigraphy of the coal-bearing rocks as it was possible at that time to get. In 1917 Mr. Martin again visited this region in a short trip to Eska and Chickaloon, and in the fall of 1918 he stopped over for a conference with members of the Alaskan Engineering Commission, Mr. Sumner S. Smith, and the writer regarding coal-mining problems.

The purpose of this report is to describe developments in the field and to record some recently acquired knowledge of the structure and stratigraphy of the coal-bearing rocks and the character and persistence of the coal beds, details of which are becoming more apparent with the opening of the underground workings.

The writer is indebted to Sumner S. Smith and George W. Evans, of the Bureau of Mines, for additional geologic data gathered by them incidental to the subdivision of the field into leasing units and to coal-mining operations. Detailed geologic information on the structure, assembled and mapped since the Alaskan Engineering Commission took over the operation of the coal mines, was placed at the disposal of the writer by Mr. Smith, resident engineer at the mines, who also cooperated and furthered the geologic work in every possible way.

The Geological Survey is further indebted to Mr. William C. Edes, commissioner, and to Mr. William Gerig, engineer in charge of the Alaskan Engineering Commission; to Mr. W. A. Gompertz, of the Chickaloon Coal Co., Mr. Henry Baxter, of the Matanuska Coal Co., and a number of others, including the mine superintendents and foremen.

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[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912.

[2] Martin, G. C., and Mertie, J. B., jr., Mineral resources of the upper Matanuska and Nelchina valleys: U. S. Geol. Survey Bull. 592, pp. 273–299, 1914.

## GEOLOGY.

### STRATIGRAPHY.

The coal-bearing rocks of the lower Matanuska Valley all occur within the Chickaloon formation, a series of shale and arkosic sandstone with intercalated conglomerate and grits estimated to be at least 5,000 feet thick. These overlie a formation consisting almost entirely of arkose. Overlying the Chickaloon formation with apparent conformity is the Eska conglomerate, a formation composed essentially of massive conglomerate with a little sandstone.

The Chickaloon formation has yielded an abundant Kenai flora and is thus regarded as upper Eocene and correlated with a part of the coal-bearing Kenai formation of Cook Inlet. The underlying arkose is also probably Eocene. The Eska conglomerate is Eocene or Miocene. On the north side of Matanuska Valley the arkose rests unconformably upon the eroded surface of the granite. At a number of localities the arkose is faulted against Cretaceous and Jurassic sediments, and no doubt in places it unconformably overlies these older sediments, which show a greater degree of metamorphism than the Tertiary rocks and whose deposition is therefore believed to have been followed by a period of deformation.

The coal occurs within the Chickaloon formation, which contains a number of coal-bearing beds. Their number, stratigraphic position, and persistence are not well known. One coal-bearing bed appears to lie near the top of the formation, just below the Eska conglomerate. Beds of coal occur at about this horizon on Moose Creek and on a tributary of Eska Creek, a mile west of the Eska mine.

The coal of the Eska mine occurs at a somewhat lower horizon and possibly close to the Cretaceous sediments, but at this place part of the Chickaloon beds are probably cut out by faulting, so that the base of the formation is not present.

At Chickaloon the coal occurs well down in the formation. Below the coal horizon there is a known thickness of at least 2,000 feet, and between the coal and the Eska conglomerate there is probably a greater thickness.

The persistence of the individual coal beds or of groups of beds is not known. Locally both the coal beds and the inclosing strata vary greatly in size and character along the strike, especially at Chickaloon, as shown in the later discussion, and probably in a general way through the entire region. At Eska the coal beds appear to be fairly persistent, but the inclosing rocks vary considerably from place to place. For this reason it is not possible to correlate the coal beds over a great distance. This habit of rapid change in the thickness is due primarily to the original lenticular character of the

sediments, but possibly it is due also in part to the crumpling and pinching out of the soft shales incident to the folding of the region.

### INTRUSIVE ROCKS.

The Tertiary sediments are invaded by felsitic and basic rocks, including granite and diorite porphyry, diabase, and gabbro. In the coal areas the felsitic rocks are mostly in the form of sills and follow the bedding planes of the sediments. The diabase and gabbro are more laccolithic in form and occur as roughly lenticular masses which have domed the strata and sent out sills and dikes into the adjacent rock. These intrusive rocks show a tendency to seek out the soft shale and the coal, which locally may be improved in chemical character by the effect of the intrusive rock but is more likely to be destroyed or injured.

### STRUCTURE.

Matanuska Valley is believed to be a sunken fault block and is bounded by two major faults parallel to the valley walls. The coal-bearing rocks are thus confined to the valley, and the surrounding mountains are made up of older formations from which the Tertiary rocks have been removed by erosion. Faulting has been so general throughout the region as to affect nearly every workable coal bed that has been opened. This faulted condition is a serious obstacle to economical mining and must always be taken into account in opening up a new tract.

At Moose Creek the faulting has temporarily hindered the development of the mine. In most places on Eska Creek the faulted parts have so far been found easily, but the coal-bearing area is known to be bounded on the north by a fault zone beyond which it is not considered feasible to prospect on account of the broken condition of the ground, and to be limited on the east also by a fault that brings it against the barren Cretaceous rocks. At Chickaloon the coal-bearing area is broken by one main fault and a series of parallel faults that limit the principal coal bed to a known length of 600 feet.

The coal beds are also closely and irregularly folded, a structural feature that will add considerably to the cost of mining the coal. The main structural features are shown in Martin's report,[1] and details of both structure and stratigraphy that were worked out in 1918 are given in the following descriptions of mines and prospects.

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[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, pl. 2, 1912.

## COAL.

### AREAL DISTRIBUTION.

The areal extent of the coal lands is described by Martin[1] as follows:

The coal of the Matanuska Valley occurs in several isolated fields. * * * The Chickaloon field is situated mostly in the lower part of the valley of Chickaloon River but extends west as far as Kings River, south across the Matanuska into the valley of Coal Creek, and possibly east beyond the Chickaloon Valley. The Eska-Moose field, which is second in area and importance, extends from the valley of Eska Creek west as far as Moose Creek and possibly into the gravel-covered area beyond it. The Young Creek field is intermediate in geographic position between the Chickaloon and Eska-Moose fields, being situated in the upper part of the valley of Young (Little Kings) Creek. * * *

The areas of the "coal-bearing rocks" can not be assumed to be underlain wholly by beds of coal of workable character and thickness. Moreover, parts of these areas may have no coal under them. The lack of knowledge as to the exact stratigraphic position of the coal beds, the uncertainty as to what stratigraphic parts of the "coal-bearing rocks" are represented by the several surface outcrops, and the concealment of the rocks by gravels over broad areas make the precise areal distribution of the coal a problem which can be solved only by drilling or other underground exploration.

The subjoined tables prepared by Martin indicate the probable and possible areas of supposed "coal-bearing" rocks in the lower Matanuska Valley as revised in 1913. These tables show the areas of probable coal occupied by the so-called "coal-bearing" rocks and overlying beds, and the possible coal areas which may be underlain by coal but in which other formations may be present.

*Areas of supposed coal-bearing rocks in the lower Matanuska Valley, in square miles.*

| | |
|---|---|
| Valleys of Chickaloon and Kings rivers | 41.1 |
| South of Matanuska River in vicinity of Kings Mountain and Coal Creek | 6.4 |
| Valley of Young Creek | 3.0 |
| Valleys of Moose and Eska creeks | 19.8 |
| | 70.3 |

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912. Martin, G. C., and Mertie, J. B., jr., Mineral resources of the upper Matanuska and Nelchina valleys, Alaska: U. S. Geol. Survey Bull. 592, 1913.

*Areas of possible extensions of the supposed coal-bearing rocks in the lower Matanuska Valley, in square miles.*

| | |
|---|---|
| Lower parts of valleys of Kings River and Granite Creek | 9.1 |
| Valleys of Moose and Eska creeks | 15.8 |
| | 24.9 |

## CHARACTER OF THE COAL.

### PHYSICAL CHARACTER.

The coal of the lower Matanuska Valley where mining has been carried on ranges in character from high-rank to low-rank bituminous. By high-rank coal is meant one that is relatively high in fixed carbon and low in volatile matter and moisture. The term high grade is used to designate a coal of any rank which is relatively free from impurities. The areal distribution of the coal of different ranks in the Matanuska Valley bears a close relation to the structure and deformation of the inclosing sediments. The low-rank bituminous coal of the Eska-Moose tract occurs in rocks that lie in a gently folded syncline, and the rocks which carry the bituminous coal of higher rank in the Chickaloon tract in the upper part of the valley are closely folded and in places tilted beyond the vertical. This dependence of the character of the coal upon the structure is further shown in the area west of Matanuska Valley. The coal found between Moose Creek and Cook Inlet all occurs in flat-lying rocks and, although evidently of about the same age as the coal of Matanuska Valley, is lignitic. These facts appear to show that the coal is of progressively higher rank toward the east, where the folding has been more intense—at least, as far as Chickaloon.

### CHEMICAL ANALYSES.

Analyses of the Matanuska coals have been published from time to time in the bulletins of the Geological Survey.[1] The following analyses of the beds now being mined at Eska were made at the time the property was under examination for the Alaskan Engineering Commission:[2]

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska; U. S. Geol. Survey Bull. 500, pp. 90–92, 1912.

[2] Smith, S. S., Alaskan Engineering Commission, Mining Dept., Report for year ending Dec. 31, 1917.

*Analyses and tests of Eska Creek coals.*

| Bed. | Air-drying loss. | Form of analysis. | Proximate analysis. | | | | Ultimate analysis. | | | | | Heating value. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Moisture. | Volatile matter. | Fixed carbon. | Ash. | Sulphur. | Hydrogen. | Carbon. | Nitrogen. | Oxygen. | Calories. | British thermal units. |
| Eska bed | 2.1 | Air dried | 2.87 | 38.86 | 40.41 | 17.86 | 0.38 | 5.28 | 63.36 | 1.46 | 11.66 | 6,327 | 11,389 |
| | | As received | 4.94 | 38.03 | 39.55 | 17.48 | .37 | 5.41 | 62.01 | 1.43 | 13.30 | 6,192 | 11,146 |
| | | Moisture free | | 40.01 | 41.60 | 18.39 | .39 | 5.11 | 65.23 | 1.50 | 9.38 | 6,514 | 11,725 |
| | | Moisture and ash free | | 49.92 | 50.98 | | .48 | 6.26 | 79.93 | 1.84 | 11.49 | 7,982 | 14,368 |
| Emery bed | 2.2 | Air dried | 3.33 | 40.00 | 46.75 | 9.92 | .34 | 5.53 | 70.05 | 1.57 | 12.59 | 7,025 | 12,645 |
| | | As received | 5.43 | 39.13 | 45.74 | 9.70 | .33 | 5.65 | 68.53 | 1.54 | 14.25 | 6,873 | 12,371 |
| | | Moisture free | | 41.38 | 48.36 | 10.26 | .35 | 5.34 | 72.46 | 1.63 | 9.96 | 7,268 | 13,082 |
| | | Moisture and ash free | | 46.11 | 53.89 | | .39 | 5.95 | 80.74 | 1.82 | 11.10 | 8,099 | 14,578 |
| Maitland bed | 4.0 | Air dried | 3.12 | 36.88 | 38.91 | 21.09 | .41 | | | | | 6,017 | 10,831 |
| | | As received | 6.99 | 35.41 | 37.35 | 20.25 | .39 | | | | | 5,777 | 10,399 |
| | | Moisture free | | 38.07 | 40.16 | 21.77 | .42 | | | | | 6,211 | 11,180 |
| | | Moisture and ash free | | 48.66 | 51.34 | | .54 | | | | | 7,940 | 14,292 |
| Maitland bed (lower bench) | 1.9 | Air dried | 3.23 | 42.82 | 46.58 | 7.37 | .65 | 5.52 | 71.69 | 1.64 | 12.33 | 7,223 | 13,001 |
| | | As received | 5.06 | 42.01 | 45.70 | 7.23 | .44 | 5.63 | 70.34 | 1.61 | 14.75 | 7,086 | 12,755 |
| | | Moisture free | | 44.25 | 48.13 | 7.62 | .46 | 5.34 | 74.09 | 1.70 | 10.79 | 7,464 | 13,435 |
| | | Moisture and ash free | | 47.90 | 52.10 | | .50 | 5.78 | 80.20 | 1.84 | 11.68 | 8,080 | 14,544 |
| Kelly bed (lower bench) | 2.5 | Air dried | 2.69 | 43.09 | 45.21 | 9.01 | .41 | 5.52 | 70.74 | 1.57 | 12.75 | 7,037 | 12,667 |
| | | As received | 5.13 | 42.01 | 44.08 | 8.78 | .40 | 5.66 | 68.96 | 1.53 | 14.67 | 6,860 | 12,348 |
| | | Moisture free | | 44.28 | 46.47 | 9.25 | .42 | 5.36 | 72.69 | 1.61 | 10.67 | 7,231 | 13,016 |
| | | Moisture and ash free | | 48.79 | 51.21 | | .46 | 5.91 | 80.10 | 1.77 | 11.76 | 7,622 | 13,720 |
| Kelly bed (upper bench) | 2.2 | Air dried | 2.74 | 42.56 | 47.61 | 7.09 | .55 | 5.81 | 72.77 | 1.68 | 12.10 | 7,320 | 13,176 |
| | | As received | 4.84 | 41.64 | 46.58 | 6.94 | .54 | 5.92 | 71.20 | 1.64 | 13.76 | 7,162 | 12,892 |
| | | Moisture free | | 43.75 | 48.95 | 7.29 | .57 | 5.65 | 74.82 | 1.72 | 9.95 | 7,527 | 13,549 |
| | | Moisture and ash free | | 47.20 | 52.80 | | .61 | 6.09 | 80.70 | 1.86 | 10.74 | 8,119 | 14,614 |
| David bed | 2.0 | Air dried | 3.60 | 42.38 | 48.40 | 5.62 | .53 | 6.84 | 72.34 | 1.66 | 13.01 | 7,226 | 13,295 |
| | | As received | 4.90 | 41.55 | 48.04 | 5.51 | .52 | 5.95 | 71.90 | 1.63 | 14.49 | 7,741 | 13,994 |
| | | Moisture free | | 43.69 | 50.52 | 5.79 | .35 | 5.59 | 75.90 | 1.71 | 10.66 | 7,614 | 13,705 |
| | | Moisture and ash free | | 46.38 | 53.62 | | .85 | 5.94 | 80.25 | 1.82 | 11.11 | 8,582 | 14,548 |

## STEAMING QUALITIES.

In 1914, 586 tons of coal from the Chickaloon mine was submitted to an exhaustive test by the Navy Department. This test, made on the U. S. S. *Maryland*, included use of coal as follows:

1. An uninterrupted period of 7 days in port.
2. A test at sea for 24 hours with not more than three-fourths boiler power, and at a speed of 15 knots.
3. A test at sea for 4 hours under full boiler power at speed of 20 knots.
4. A test at sea of 40 hours at speed of 10 knots.

The Navy Department also submitted the coal to laboratory tests and to full analyses. As a result of these tests the board appointed to pass on the coal reported[1] that "the sample of Matanuska coal tested is suitable in every respect for use in the naval service."

## COKING AND BY-PRODUCT QUALITIES.

A field test of the coking qualities of the Chickaloon coal was made in 1905 by Martin[2] who says:

> The resulting coke was hard and firm and had a good ring and a good texture. The test indicated that by proper treatment a coke of satisfactory grade can be produced. No further tests have been made by members of the Geological Survey. The analyses indicate, however, that the high-grade bituminous coal on Chickaloon and Kings rivers and on Coal Creek is probably, at least in part, coking coal, and that the coal in the west end of the district, on Moose, Eska, and Young creeks, is low-grade bituminous and is probably all noncoking.

In 1918 a coking test on 6 tons of washed Chickaloon coal was made by the Bureau of Mines at the Wilkeson coking plant of the Wilkeson Coal & Coke Co., under the direction of George W. Evans. The analyses of the coal used for the test and of the resulting coke given below are taken from an informal report to the Alaskan Engineering Commission.

*Analyses of Chickaloon coal used in coking test at Wilkeson coking plant and of resulting coke.*

| | Moisture. | Volatile combustible. | Fixed carbon. | Ash. | Sulphur. |
|---|---|---|---|---|---|
| Coal | 1.0 | 22.52 | 65.87 | 10.61 | 0.49 |
| Coke | .55 | .70 | 85.45 | 13.30 | .57 |

The coke is reported by Mr. Evans to be of good appearance, and a foundry test made on about 3 tons of it by the Puget Sound Iron & Steel Works, of Tacoma, Wash., was satisfactory and indicates its suitability for foundry purposes.

[1] Sixty-fourth Cong., 1st sess., S. Doc. 26, p. 9, 1915.

[2] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, p. 92, 1912.

The following report was made by F. W. Speer, jr., on a sample of coal taken from bed 8 at Chickaloon, submitted by the Bureau of Mines to the laboratory of H. Koppers Co., Mellon Institute, Pittsburgh, Pa.:

| | | |
|---|---|---|
| Proximate analysis: | | |
| Volatile matter | | 21.14 |
| Fixed carbon | | 72.37 |
| Ash | | 6.49 |
| Sulphur | | .57 |
| Distillation: | | |
| Water | | 3.077 |
| Carbon dioxide | | .787 |
| Hydrogen sulphide | | .088 |
| Composition of gas (calculated to oxygen-free basis): | | |
| $C_nH_m$ | | 2.6 |
| CO | | 4.9 |
| H | | 60.4 |
| $CH_4$ | | 29.8 |
| $N_2$ | | 2.3 |
| Ratio: $\frac{\text{Fixed } NH_3}{\text{Total } NH_3}$ | | .033 |
| Specify gravity of gas | | .30 |
| British thermal units in gas per pound of coal | | 2,979 |
| Practical yields per net ton: | | |
| Tar | gallons | 4.4 |
| Sulphate | pounds | 20 |
| Gas at 15° C., 760 mm. Hg | cubic feet | 10,850 |
| Coke | per cent of coal | 81.3 |
| Light oil (estimated to contain 55 per cent benzol and 12 per cent toluol) | gallons | 1.9 |

Remarks: This is a coking coal similar in quality to Pocahontas. It would probably produce a similar coke, but the exact character of the coke can only be determined by making an oven test. Such coal usually requires mixing with some high-volatile coal in order to avoid trouble due to expanding and sticking.

The possibility of the utilization of the Matanuska coals for their by-products should be investigated when sufficient coal reserves are developed. A ton of bituminous coal will produce in round numbers 10,000 cubic feet of gas, three-quarters of a ton of smokeless fuel, 20 pounds or more of ammonium sulphate, 2 gallons of light oil, and from 4 to 9 gallons of tar. The carbon residue when briquetted furnishes a fuel approaching hard coal in value, and both it and the gas might be used for industrial and domestic purposes. Recoverable by-products that would find a local market are tar for road dressing, ammonium sulphate for fertilizer, and benzol for motor oil. Other by-products are toluol, essential in the manufacture of high explosives, dyes, and chemicals.

## MINING.

### DEVELOPMENT.

The coal-land leasing act passed by Congress in 1914 provided for the survey of lands in Alaska known to be valuable for their deposits of coal and the division of such coal lands not reserved for naval and other governmental uses into leasing blocks or tracts. The Matanuska coal field, which was designated in the act as one of the fields to which preference was to be given, was subdivided in 1915 into 19 leasing units and Government reservations, and on May 8, 1916, the leasing units were offered for leasing by the Secretary of the Interior.[1]

The same year some coal was mined on Moose Creek, at the Doherty mine, which was operated on a 10-acre permit, by the Doherty Coal Co.

The lease on units 2 and 3 on Moose Creek was granted early in 1917, and work on this property, known locally as the Baxter mine, was started in October. From December, 1917, to April, 1918, coal was mined and sledded to Moose Creek for shipment to Anchorage, where it was taken in part by individuals and in part by the Alaskan Engineering Commission.

The Eska Creek Coal Co. took over the lease originally obtained by William Martin for unit 7 on Eska Creek and began mining coal in January, 1917. The coal was sledded 3 miles to the Matanuska branch of the railroad at Sutton until the Eska spur was built. The production at first was only about 35 tons a day, but the exposures indicated extensive coal resources, and upon the promise of a large tonnage the spur line was built to the mines. The mining operation, however, soon ran into faulted ground, and production stopped.

In February of the same year a lease on units 10 and 11, between Chickaloon and Kings rivers, was granted to Lars Netland for the Chickaloon Coal Co., which began active developments on the property.

The outlook for an adequate supply of coal for the railroad was not very bright. Operations at Eska were hampered by faulted ground and by lack of time and capital for exploration and development work. The Baxter leasehold on Moose Creek was still in the prospect stage, and the coal deposits were 4½ miles from the railroad. The coal produced at the Doherty mine was of poor quality and insufficient in quantity to meet the needs of the commission. The available coal was about 100 tons a day, only about half the amount necessary to supply the needs of the commission.

[1] Regulations governing coal-land leases in the territory of Alaska, Interior Dept., 1916.

The commission, having realized the risk of relying upon private interests to supply an adequate supply of coal for the needs of the railroad, had requested that unit 12 be set aside for its use. No coal from this unit or from the lease of the California Coal Co. on units 10 and 11 could be available, however, until the completion of the Matanuska branch of the railroad to Chickaloon.

In the spring of 1917 Sumner S. Smith and George W. Evans, of the Bureau of Mines, made an investigation of the conditions of mining in the Matanuska field, as regards safety precautions observed underground and methods of mining and treating the coal, and reported to the Alaskan Engineering Commission[1] the conditions as outlined above, and recommended that the Alaskan Engineering Commission either offer the Eska Creek Coal Co. a contract that would enable it to install the proper equipment to explore the faulted ground and other known beds or purchase or lease unit 7 from the Eska Creek Coal Co. and mine coal for its own use until explorations by private operators in other parts of the fields had developed mines large enough to supply the necessary amount of coal.

The Alaskan Engineering Commission finally purchased the property and took over the lease on June 18, 1917, the same day that unit 12 on Chickaloon River was set aside by Executive order for the use of the commission. Sumner S. Smith was placed in charge of the Government-controlled properties at Eska and Chickaloon and began the active development of the mines. In 1918 the Eska mine produced over 150 tons a day throughout the year. At Chickaloon 4,000 tons of coal was mined incidental to prospecting and development operations. Recent developments are recorded in the descriptions of the mines and prospects.

## PRODUCTION.

The production of the Matanuska coal fields for 1918 was 63,091.6 tons. This coal came from three properties—the Baxter mine, on Moose Creek, which operated for a part of the year, and the Government-operated mines at Eska and Chickaloon. The greater part of the output was from Eska, where an average of over 150 tons a day was maintained throughout the year. This does not represent a capacity production, for the Alaskan Engineering Commission has been mining coal primarily for its own use on the railroad and has mined only enough to supply its needs and keep a reasonable surplus on hand. The output of 4,180 tons from Chickaloon was obtained from development operations. The lack of transportation facilities

[1] Smith, S. S., Alaskan Engineering Commission, Mining Dept., Report for year ending Dec. 31, 1917.

at the Baxter mine obviously limits the productive mining season to the winter, when the coal can be sledded to the railroad.

There appears to be little prospect of an increased production in 1919 except through Government activities. Private interests have not yet successfully developed a mine. The Chickaloon Coal Co. is actively prospecting its ground, but so far has not met with enough success to give much hope of making a production during the coming year. The Baxter mine will require transportation facilities and considerable development to bring it to the productive stage, beyond the mining out of a block of coal in the fault block. This mine is now (1918) idle, and no development work has been done for some months.

Chickaloon is still in the prospect stage.[1] The detailed geologic work done in 1918 indicates that the beds are very lenticular and vary greatly in size and character from place to place, and that the main bed, on which the principal hopes of developing the mine are based, either feathers out within a distance of 1,000 feet or less into a number of small beds of inferior coal or is faulted to such an extent that the bed has not been located in the underground workings. At Eska there is coal enough in sight to last several years at the present rate of mining, and the production could be considerably increased if necessary.

*Coal produced in the Matanuska field, 1916–1918, in short tons.*

| | |
|---|---|
| 1916 | 8, 395 |
| 1917 | 45, 370 |
| 1918 | 63, 092 |
| | 116, 857 |

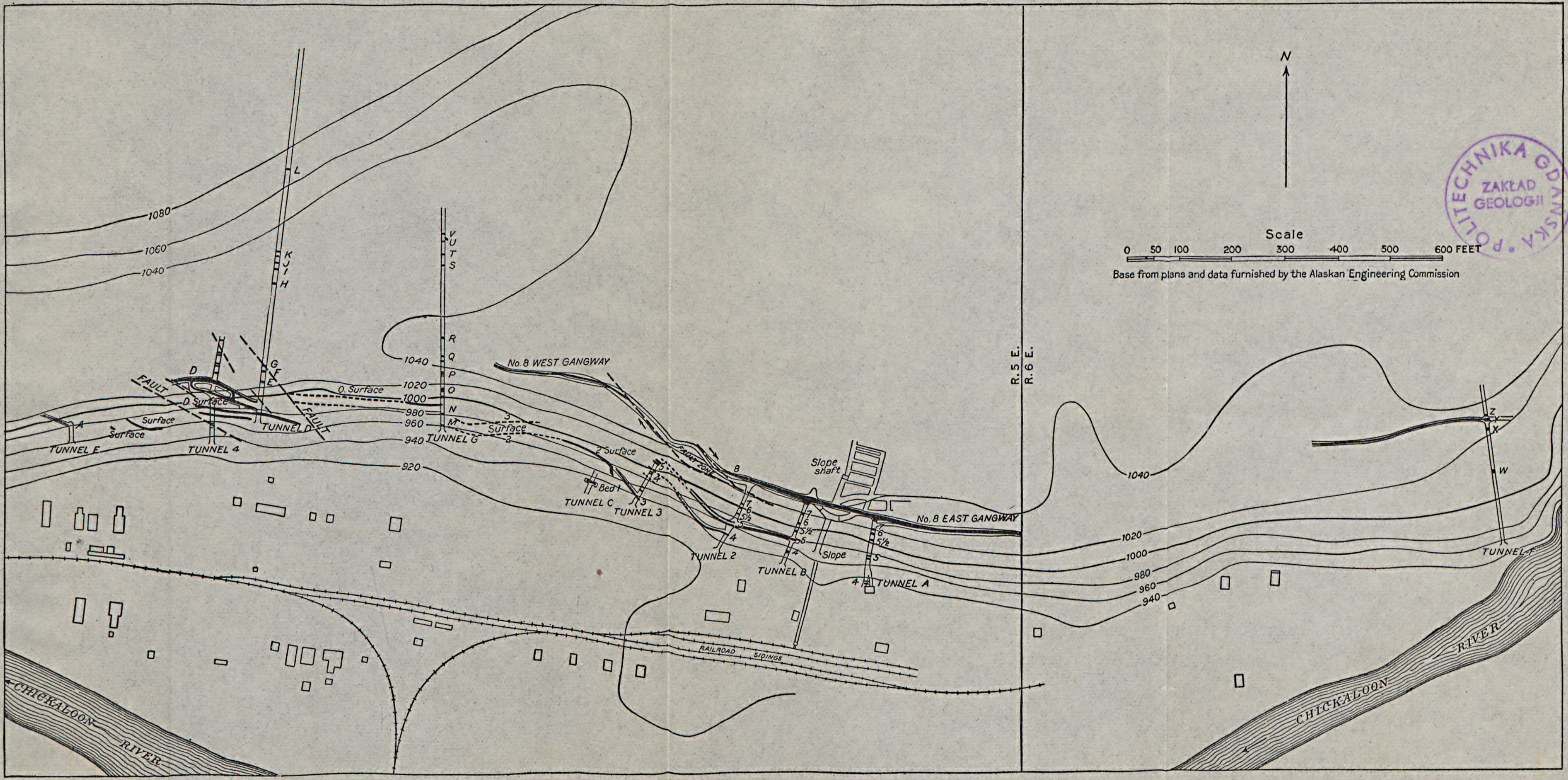
## CHICKALOON MINE.

### LOCATION AND DEVELOPMENT.

The Chickaloon coal mine is on leasing unit 12, at the terminus of the Matanuska branch of the railroad, 75 miles from Anchorage.

The coal crops out on the north bank of Chickaloon River, which at this place has cut through the gravel covering and underlying coal measures and exposed the coal beds in a bluff that rises 100 feet from the alluvial flat of the river to a terrace covered with glacial gravels.

[1] Since the above was written mining developments have been continued at both the Eska and Chickaloon mines. At Eska about 150,000 tons of coal has been definitely blocked out, and the coal beds now being mined have been traced at the surface by open cuts for about a mile, indicating, according to S. S. Smith, a coal reserve of about 1,000,000 tons. At Chickaloon a slope has been sunk for 600 feet, and over 100,000 tons of high-grade blacksmith coal has been blocked out.—A. H. Brooks.




SKETCH MAP OF WORKINGS OF THE CHICKALOON COAL MINE, SHOWING PRINCIPAL FAULTS AND LOCATION OF COAL BEDS.

The mine is being developed by a number of crosscut tunnels and connecting drifts driven along the best coal beds. The coal measures exposed on this bluff and by the underground workings stand nearly vertical and in places are overturned, so this method of driving tunnels perpendicular to the strike gives a crosscut approaching the stratigraphic section and appears to be an economical way of exploring the measures underground to determine the structure and stratigraphy of the rocks and the continuity of the coal beds, for the area is largely covered with glacial gravel and even the outcrops on the banks of streams are partly concealed by talus. The nine tunnels (Pl. IV) in order of sequence from east to west are numbered F, A, B, 2, 3, C, G, D, 4, and E.

In these workings 10 or more coal beds have been cut, and the best ones have been explored by drifts along their strike. The principal work has been done on what is known as bed 8, a 17-foot bed of coal which has been opened by a gangway and counter along its strike for 600 feet and explored by a shaft to a depth of 583 feet. The present scheme of development is simply a continuation of the prospecting work started by the private operators who endeavored to open up the coal beds and is designed to prospect the tract and to determine the character and extent of the workable coal beds.

When the Chickaloon mine was taken over for operation by the Alaskan Engineering Commission tunnels A, B, 2, 3, D, 4, and E had been started by the former operators. Tunnels A and B had been driven to bed 8 and a drift extended along it for 300 feet. Bed 5 also was opened by a drift from tunnel B to tunnel 2, and drifts extended westward from tunnel B along beds 4 and 5. Tunnels 4 and D had each been driven about 100 feet, and 250 feet of connected workings extended from them on bed D.

The first work of the commission was to sink a working shaft on bed 8 between tunnels A and B, to continue tunnel 2 to bed 8, to extend the gangway along bed 8 both east and west, to extend tunnels 4 and D 90 and 250 feet, respectively, and to drive tunnel F 170 feet. All this work was done in 1917.

During 1918 the shaft was continued to a depth of 583 feet, the east and west gangways and counters on bed 8 were extended to a total length of 1,080 feet, tunnel D was driven to a length of 780 feet, the drifts on bed D were extended from tunnel H, and tunnel G was driven 400 feet. This work has all been in the nature of prospecting. In driving westward on bed 8 a prominent fault was encountered, which displaced the bed toward the northwest, and tunnels D and G were driven to prospect the fault block west of the fault, and if possible to find the faulted part of bed 8.

Tunnel D crosses a number of coal beds, but as none of these resembled the coal in the eastern tunnels, it was continued until a thick barren zone was entered and the work was stopped temporarily. Tunnel G was then driven, and a number of coal beds were cut. None of these can, with certainty, be determined as bed 8, but some suggested correlations are presented in this report.

Tunnel F was driven 300 feet, and drifts extended east and west, respectively, 45 and 340 feet along bed Y, the possible equivalent of bed 8.

The mine is equipped with bunk houses, hospital, dining room, dry house, power plant, fan houses, blacksmith shop, office buildings, storehouses, and barns. There are also a number of private buildings, including road houses, stores, barber shop, pool hall, and laundry. The resident engineer in charge maintained temporary headquarters at Chickaloon during the summer of 1918 but moved in November to Eska.

## GEOLOGY.

### STRATIGRAPHY.

The stratigraphic section exposed in each tunnel of the Chickaloon mine is shown in Plate V. The correlation of the coal-bearing beds, however, is in doubt. The outcrops are too scattered and gravel-covered to be followed on the surface for any distance, and the coal beds have no distinct markers or other characteristics that serve to identify them, and they vary so greatly in size of bed and character of coal that it is not easy to recognize a bed from place to place solely on its physical appearance. The inclosing rock formations also change along the strike in thickness and character and are lacking in any distinct persistent markers that might serve to correlate one section with another. The sections exposed by tunnels A, B, 2, and 3, although showing considerable variation from place to place, are similar enough to permit correlating the coal beds, at least, without much doubt. The same may be said of the sections exposed in tunnels G, D, and 4, but between the sections exposed in these two groups of workings there is much less similarity. Bed 8, for instance, in tunnels A, B, and 2 is about 17 feet thick, but there is nothing to correspond to it in size or general appearance to the west. This at first led to the belief that bed 8 had been carried by the fault beyond the faces of tunnels G and D, and that the section exposed in these tunnels is stratigraphically below the rocks cut in tunnels A, B, and 2.

This does not seem probable, however, for, as is brought out later, there is no indication of faulting of such magnitude, and besides the beds cut by tunnels A, B, and 2 appear to be the same as a part

of those in tunnels G and D. This correlation was established by digging a series of pits, by means of which it was possible to trace and project beds 2 and 3 across the partly concealed interval between the bluff above tunnel C and the mouth of tunnel G. Inasmuch as the stratigraphic relation of these two sections is important on account of its bearing on the position and character of bed 8—as indicating whether that bed occurs in tunnels G and D or is to be looked for elsewhere—the following correlations are suggested as probable, though not positively proved. Even with beds 2 and 3 identified near the mouth of tunnel G and used as a starting point it is not possible to correlate the overlying beds with certainty.

The most plausible correlation is made by assuming that bed 8 has split up into a number of benches and is represented by beds H, I, and J in tunnel G and S, T, and U in tunnel D. The underlying beds, 7 to 2, are correlated with those exposed in tunnels G, D, and 4 as brought out in the following discussion.

An alternative correlation, which was at first made, is to consider the upper part of bed O in tunnel G as the two benches of bed 5 and to correlate beds E and P with 5½, 6, and 7; beds F and Q with 8; and beds G and R with 9. This correlation seems much less probable than the other, as it would indicate a thinning out toward the west of the rocks between the coal beds, a supposition which is contrary to the observed facts.

If the correlations that follow are correct, the known coal beds exposed on Chickaloon River occur in three groups of beds separated by barren intervals of shale and sandstone forming a series of rocks 600 to 750 feet thick, which strike about east. The normal dip is toward the north, but in places the beds are folded beyond the vertical and actually dip toward the south.

Bed 1 is exposed in tunnel C but does not show in any of the workings to the east and crops out for only a short distance on the surface. It is possible that this is the same as bed A in tunnel E, which is composed of 11 feet of carbonaceous shale and coal. Bed 1 in tunnel C contains about 3 feet of coal and shows little resemblance to bed A, but this correlation is suggested by the relation of each to overlying beds.

Bed 2 crops out above tunnel C but is not cut in any of the tunnels to the east. It contains about 3 feet of bony coal underlain by 2 feet of carbonaceous shale and bone. Bed 2 was traced westward from the bluff above tunnel C and is believed to have been identified as bed M near the mouth of tunnel G. Beds B and M also are believed to be the same bed.

Bed 3 crops out on the bluff above tunnel C and is cut by tunnel 3 and opened by a drift for 60 feet. It is also believed to be the

same as bed N in tunnel G and as bed C, which is cut in tunnel 4 and which crops out on the hillside between tunnels 4 and E. On the surface above tunnel 3 it is 3 feet thick, and occurs in two benches of clean, bright coal separated by 1 foot of bony coal with silicified tree trunks. In tunnel 3 bed 3 is 3½ feet thick. The upper half of the bed is good, clean coal, but the lower part contains much bone and dirt and in places silicified tree trunks. Toward the west the bed improves, and at the face of a 60-foot drift driven from tunnel 3 it has the following section:

*Section of bed 3 at west end of drift from tunnel 3.*

| Shale roof. | Ft. | in. |
|---|---|---|
| Carbonaceous shale | | 5 |
| Bright coal | 2 | 6 |
| Hard shale | | 1 |
| Coal | | 6 |
| Bone | | 2 |
| Massive shale floor. | | |

In tunnel G, bed N is composed of 2 feet of bony coal. Bed C in tunnel 4 has about 18 inches of bony coal, and where it crops out west of the tunnel it is from 1½ to 2 feet thick and contains the characteristic silicified tree trunks.

Bed 4 is cut by tunnels A, B, 2, and 3 and crops out on the surface above them. In tunnel 3 it has 2 feet 4 inches of coal, overlain by 3½ feet of bone and shale, but is very lenticular and decreases toward the east. In tunnel 2 it contains about 2 feet of coal and bone, and in tunnels B and A it contains only lenses of coal ad carbonaceous shale.

Bed 4 is correlated with bed O in tunnel G and bed D in tunnels D and 4. If this correlation is correct, it increases in value toward the east at least as far as tunnel 4. Farther west bed D evidently pinches, and in the workings of the Chickaloon Coal Co. merges into carbonaceous shale. In tunnel G, strata which are correlated with bed 4 contain 19 feet of coal and shale. If this correlation is correct, bed 4, besides increasing in thickness, is also splitting up into benches toward the west. Bed O crops out on the surface westward from tunnel G nearly to tunnel D, where it appears to have been faulted from bed D, with which it is believed to have been at one time continuous.

Much uncertainty exists regarding the identity of bed D in tunnel D and bed O in tunnel G. The position of the outcrops of these two beds would indicate that they are not the same and that bed D is much lower stratigraphically, unless a fault separates these two beds. The trace of a fault occurs on the surface between the outcrops of the beds, along which the movement may have taken

place that brought them to their present position. The faulting, however, may have been in the opposite direction, and bed D may occur below any beds cut by tunnel G.

Bed D is opened by tunnels 4 and D and by connecting workings and crops out on the surface for 200 feet. It is from 5 to 8 feet wide and swells and narrows within a short distance. It is also badly crushed and broken by many faults. None of these are believed to be extensive, but they have offset the bed in a number of places and will greatly increase the cost of mining it.

Bed 5 has been opened by tunnels A, B, 2, and 3, and wherever exposed shows two benches except in tunnel 3, which evidently is not extended far enough to cut the upper part. In tunnel 2 bed 5 has the following width:

*Section of coal bed 5 in tunnel 2.*

| | | Ft. | in. |
|---|---|---|---|
| Coal (bed upper 5) | Bone and coal | 1 | 6 |
| | Coal | 2 | 6 |
| | Bone and coal | 2 | |
| Carbonaceous shale and bone | | 3 | |
| Coal (bed lower 5) | Coal with some bone | 3 | 10 |
| | Carbonaceous shale and bone | 1 | 2 |

Bed 5 decreases in size and becomes poorer in quality toward the east. In tunnel B the upper and lower benches are respectively $5\frac{1}{2}$ and 3 feet thick and are separated by 1 foot of shale and bone. In tunnel A it has merged into two beds of carbonaceous shale with a parting of nodular shale. In tunnel 3 bed 5 is composed of 5 feet of dirty coal. This is evidently the lower bench.

Bed 5 is correlated with bed P of tunnel 4 and E of tunnel D. Bed P occurs in three benches aggregating $4\frac{3}{4}$ feet of coal with a thick shale parting. Bed E is 2 feet 8 inches thick but contains large niggerheads.

Bed $5\frac{1}{2}$ is exposed in tunnels A, B, and 2. In tunnel B it contains $3\frac{1}{2}$ feet of bony coal, but in tunnels A and 2 it is less than 3 feet thick and is more bony. Bed $5\frac{1}{2}$ is believed to be the same bed as Q and F.

Bed 6 is also exposed in tunnels A, B, and 2. In tunnel B it has the following thickness:

*Section of bed in tunnel B.*

| | Ft. | in. |
|---|---|---|
| Coal | | 6 |
| Shale | | 6 |
| Coal | 1 | 6 |

In tunnel A it contains 3 feet of coal with some bone. In tunnel 2 it is $2\frac{1}{2}$ feet thick and contains some impurities. It is correlated with beds R and G and also with bed W in tunnel F and the bluff east of it.

Bed 7 as exposed in tunnel 2 is about 1 foot thick. In tunnel B it has merged into 6½ feet of carbonaceous shale with streaks of coal, and in tunnel A is a narrow bed of impure coal. It is possibly bed X in tunnel F and on the bluff exposure near by. Bed 7 is not correlated with any coal bed in tunnels D or G. It may have pinched out or may have merged into one of the shale beds between beds R and S and between G and H.

Bed 8 is exposed near the face of tunnels A, B, and 2 and has been opened by a gangway and counter for 600 feet and explored by a shaft to a depth of 583 feet. In all these exposures it maintains a width of about 17 feet between walls. The following section is taken from a published report:[1]

*Section of bed 8 in tunnel B.*

| | Ft. | in. |
|---|---|---|
| Coal with shale and bony beds. | | |
| Coal | 1 | 6 |
| Shale | | 3 |
| Coal | 4 | 3 |
| Shale | | 2 |
| Coal | 1 | 1 |
| Irregular shale mass | | 5 |
| Coal | | 11 |
| Shale | | 8 |
| Coal | | 11 |
| Shale | | 4 |
| Coal | 1 | 6 |
| Shale with many coaly beds | | 11 |
| Coal | 4 | 2 |
| Shale with coal and bone partings. | | |

Bed 8 is faulted in both the east and west gangways, and the object of much of the prospecting has been to find the faulted part of the bed. So far this has not been done with certainty, but correlations are suggested in harmony with those already made for the lower beds. Toward the west bed 8 is believed to have split up into three branches and in tunnel G to be represented by beds S, T, and U and in tunnel D by beds H, I, and J. Beds S, T, and U contain about 14 feet of coal, nearly as much as the actual coal in bed 8 but broken up into smaller beds and mixed with much shale. Beds H, I, and J in tunnel 4 contain considerably less coal, and the beds in tunnel 3 of the Chickaloon Coal Co., with which these beds are correlated, are smaller yet. If this correlation is correct, therefore, it appears that bed 8 breaks up into benches and thins out toward the west. The largest of the supposed equivalents of beds H, I, J, and K, in Chickaloon Coal Co. tunnel contains 2½ feet of good coal, but the other beds are from 1½ to 2 feet thick and are separated by an aggregate of over

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, p. 79, 1912.

60 feet of shale. This correlation of bed 8 with beds H, I, and J implies a progressive thickening of the stratigraphic section toward the west and is in keeping with conditions in tunnels A, B, and 2.

Bed 8 is possibly also the same as bed Y in tunnel F and on the bluff near by. If so, bed 8 has thinned out greatly between the face of the No. 8 east gangway and tunnel F. Where first cut in tunnel F it has a thickness of 3 feet. Along the drift to the west it pinches and widens but maintains an average width of 2½ feet or more. The correlation of beds 8 and Y is suggested with considerable doubt. Beds X and Y may be the equivalent of bed 8, or the entire section exposed in tunnel F may be at a horizon entirely different from that of the beds exposed in any of the other workings.

Bed Z in tunnel F, bed 9 in tunnels A, B, and 2, bed V in tunnel

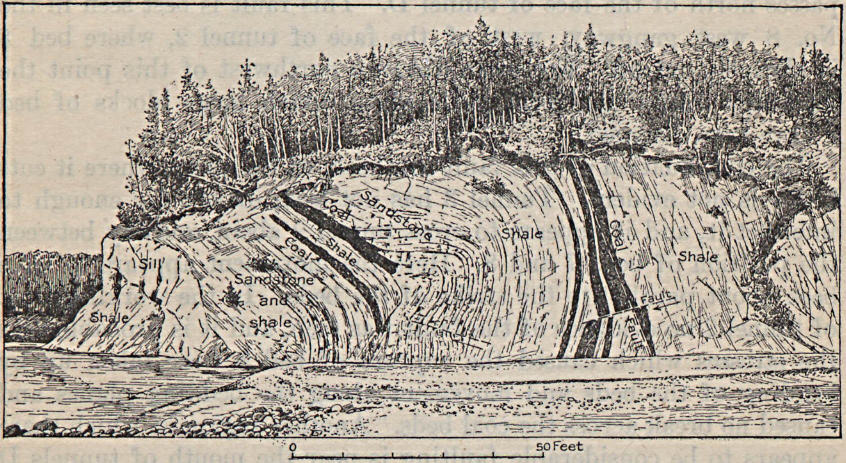



FIGURE 2.—Sketch of bluff on Chickaloon River above Chickaloon mine.

G, and bed K in tunnel D are correlated, a conclusion that follows from the foregoing deductions.

## STRUCTURE.

The coal-bearing rocks of Chickaloon lie in a monoclinal block broken by one main fault and a number of minor parallel ones. In the western part of the tract the beds dip from 25° to 50°, but toward the east the dips become steeper. The normal dip is toward the north, but in the southeastern part of the tract the beds are folded beyond the vertical, at one place more than 180° from their original position. The strike ranges from N. 70° W. to N. 80° E.

The folding is marked by very sharp flexures, which in places pass into actual breaks that have faulted the coal beds. (See fig. 2.)

One main fault crosses the tract with a general northwesterly strike and nearly vertical dip. The movement appears to have been

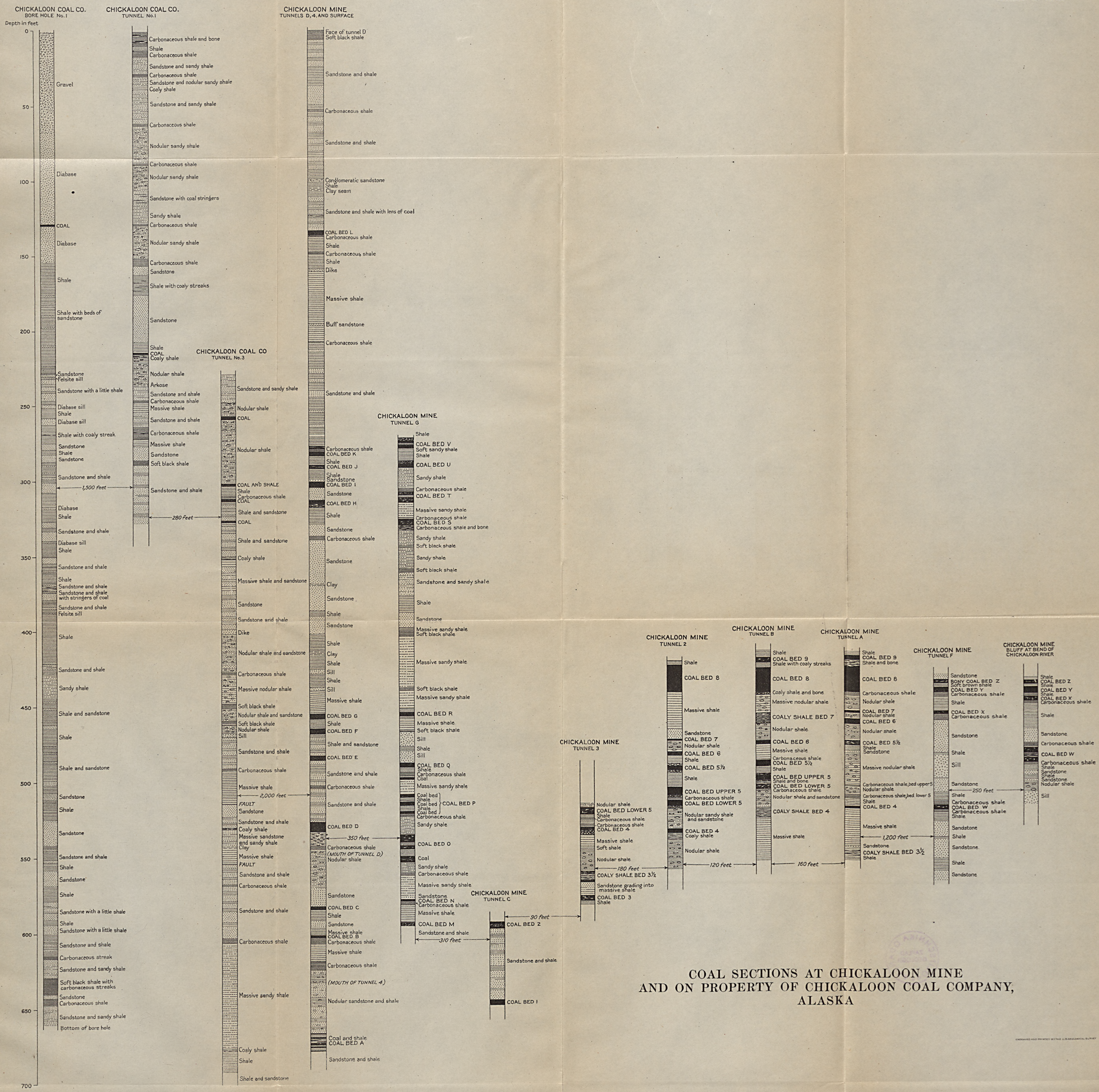
nearly parallel to the strike of the fault, so that the heave or horizontal component of the movement nearly represents the actual displacement. The faulting did not occur along a single plane but was distributed over a zone from 50 to 70 feet wide. The relative movement of the northeast block toward the southeast is readily seen by the bending of the coal beds as shown on Plate IV.

The amount of displacement along the main fault is not known, for the faulted part of bed 8 southwest of the fault has not been positively identified. If the conclusions drawn are correct, the horizontal displacement along the fault plane is about 650 feet, and if bed 8 is exposed in any of the tunnels southwest of the fault the displacement must have been at least 350 feet. The fault near the face of tunnel G is believed to be this main fault, which evidently passes north of the face of tunnel D. This fault is best seen in the No. 8 west gangway, west of the face of tunnel 2, where bed 8 is abruptly cut off. For some distance northwest of this point the workings follow the fault plane along which large blocks of bed 8 have been dragged.

The continuation of this fault southeast of the point where it cuts bed 8 is not evident. Tunnel 3 has not been driven far enough to intersect it, and it appears to cross tunnel 2 about midway between the position of beds 7 and 8. Here the movement appears to have been about parallel to the strike of the beds. In the workings east of tunnel 2 no evidence of the fault was seen, and it is probable that the stresses which caused the rupture of bed 8 were taken up by bending of the beds and movement along the bedding planes and caused no break across the coal beds. Another region in which there appears to be considerable faulting is near the mouth of tunnels D and 4, both in the underground workings and on the surface, but none of the faults are known to be extensive.

If the correlations made between beds exposed in tunnel G and in tunnels D and 4 are correct, there appears to be faulting at this place, in which the horizontal displacement was in the opposite direction to that caused by the main fault.

East of the main fault the beds are greatly compressed, stand at high angles, and are partly overturned. West of the main fault except where locally disturbed by faulting the structure is more regular; the beds are nowhere overturned and dip at much lower angles. These favorable structural conditions, however, are more than offset by the unfavorable condition of the coal beds, which toward the west break up into smaller beds with shale partings or pinch out entirely.




COAL SECTIONS AT CHICKALOON MINE AND ON PROPERTY OF CHICKALOON COAL COMPANY, ALASKA

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

## CHICKALOON COAL CO.'S PROPERTY.

### LOCATION AND DEVELOPMENT.

The Chickaloon Coal Co., of San Francisco, holds a lease on units 10 and 11 on Chickaloon River. The lease was procured for the company by Lars Netland, engineer, in February, 1917, and the following July W. A. Gompertz, superintendent, and Mr. Netland returned and made an examination of the property and reported to the company. Development work was started in November, 1917, and has since continued with a small crew of men.

The underground developments to date consist of three tunnels, with an aggregate of 1,350 feet; one diamond-drill hole, 658 feet deep, and another one being drilled. The mine camp is at the mouth of Louise Creek, a small stream that enters Chickaloon River at the sharp bend 1½ miles above its mouth.

### GEOLOGY.

The tract that is being explored for coal is occupied by shale and sandstone of the Chickaloon formation. The rocks lie in a monoclinal block, in which the beds strike from east to northeast and dip north to northwest at angles of 35° to 60°. The beds are apparently less disturbed than at the Chickaloon mine; no faulting of any magnitude occurs, and the folding is more uniform than on unit 12.

The rocks cut by the bore holes and tunnels on unit 11 correspond approximately in stratigraphic position to the beds exposed in the workings of the Chickaloon mine. Tunnels 1 and 3 together cut across a section which is believed to be continuous, except for a possible small gap or duplication between the face of tunnel 3 and the mouth of tunnel 1. This section extends from the railroad track along the river nearly to the gabbro mass that makes up the hill below United States land monument 3. The drill hole cuts a section a part of which is believed to be stratigraphically higher than the beds exposed in tunnels 1 and 3.

The stratigraphic sections are shown graphically in Plate V. The drill hole was driven at an angle of 50°, as nearly perpendicular to the bedding of the rocks as possible, so the section with the exception of the gravel and igneous rocks approximates the stratigraphic section.

The correlations suggested between the beds in the tunnels and those at the Chickaloon mine, sections of which are shown in Plate V, seem possible, but much doubt exists concerning any correlation between the rocks of the tunnels and the drill hole. Stratigraphically the drill section appears to extend higher than the other, but

between the two localities there is a concealed interval of 1,500 feet and the structure is inferred from outcrops along the river.

The lower coal group of beds, which includes beds A to G in the workings of the Chickaloon mine, is believed to correspond to the beds of carbonaceous shale which are shown in the lower half of the coal section exposed in tunnel 3 of the Chickaloon Coal Co. The coal beds exposed near the mouth of tunnel 3 are correlated with beds H, I, J, and K of the Chickaloon mine, and coal bed L is believed to correspond to the bed of carbonaceous shale near the mouth of tunnel 1 or the small bed of coal above it.

If these suggested correlations made between the rocks at the Chickaloon mine and those exposed in the workings of the Chickaloon Coal Co. are correct, the coal beds all diminish in size toward the west from the Chickaloon coal mine, and some of them disappear entirely. This appears to limit the coal-bearing tract of the Chickaloon mine on the west. This fact does not condemn the property of the Chickaloon Coal Co., for the area prospected is only a small part of the leasehold, which should be tested for other possible coal-bearing areas to the west and north of the present workings.

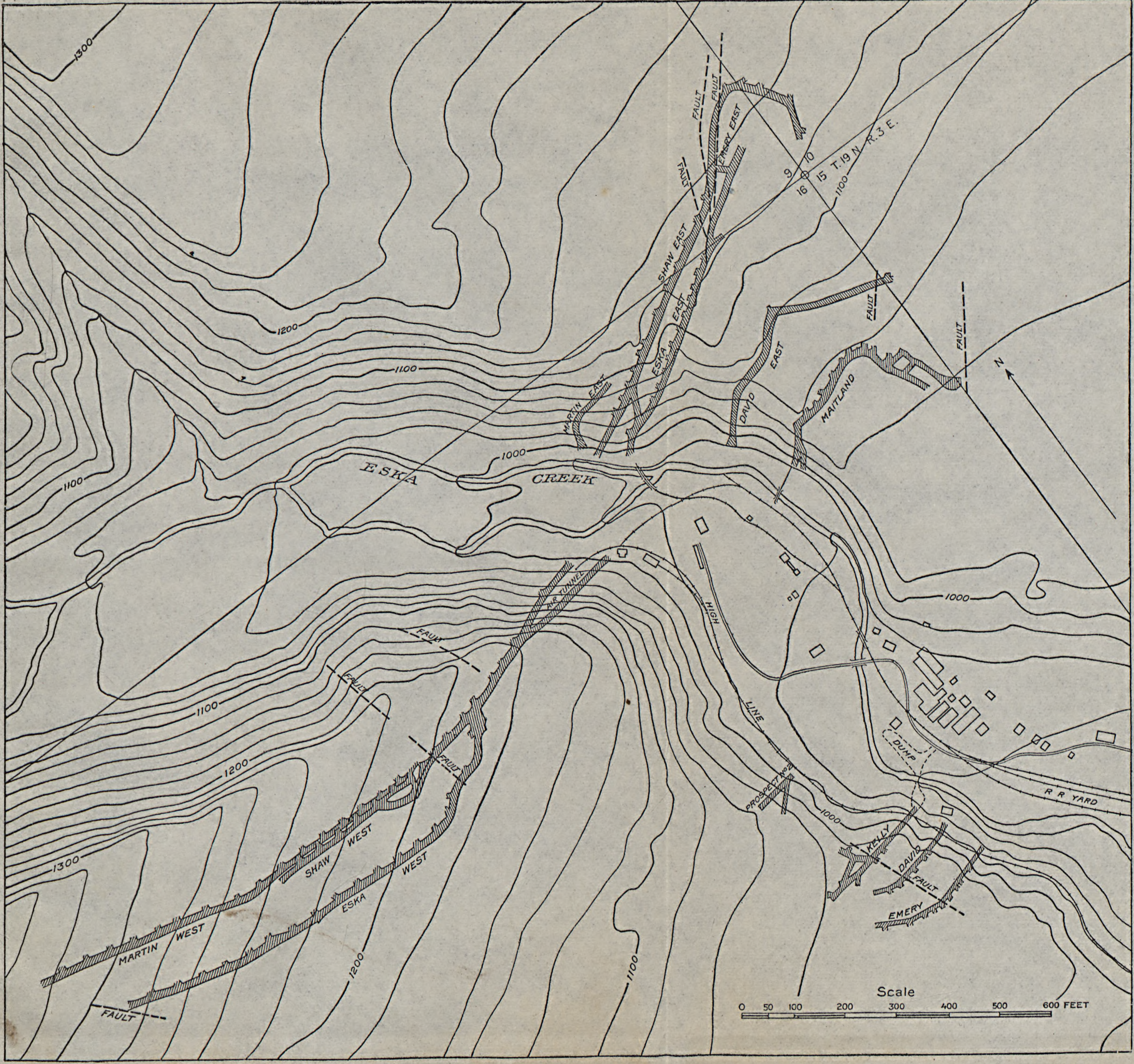
## ESKA MINE.

### LOCATION AND DEVELOPMENT.

The Eska mine is 60 miles from Anchorage, on leasing unit 7, and is reached by a short spur that connects with the Matanuska branch of the railroad at Sutton.

The coal outcrops at Eska occur on both banks of Eska Creek, which cuts across the strike of the coal-bearing rocks. The mine is being developed by drift tunnels extended along the coal beds a few feet above the level of the creek. Ten such openings have been made on coal beds, and three of them are working entries. Six workable beds of coal are being mined, known as the Martin, Shaw, Eska, Emery, David, and Kelly or Maitland. As most of these beds have been identified on both sides of Eska Creek, the suffix east or west is used with the name of the bed or entry to indicate the side of the creek on which the bed occurs or the entry is driven.

Development at Eska was started in January, 1917, by the Eska Creek Coal Co. The first mining was done on the Emery, David, and Kelly beds on the west side of Eska Creek. Entries were driven along these coal beds to a fault which cuts off the coal in all three tunnels, and the coal above drainage level was mined out and the workings abandoned. The Eska Creek Coal Co. also started entries on the outcrops of the Eska and Maitland beds on the east side of Eska Creek.




TOPOGRAPHIC MAP OF COUNTRY AROUND ESKA COAL MINES, SHOWING FAULTS.

The Alaskan Engineering Commission has opened up the Eska, Shaw, and Martin beds on both sides of the creek and the Emery, David, and Maitland on the east side. About 2,300 feet of churn drilling was done in 1918 to prospect the ground east of Eska Creek, and a prospect shaft was put down to explore one of the beds cut. Another prospect is a tunnel being driven to open the David and Emery beds west of Eska Creek on the north limb of the syncline (Pl. VI). The Eska, Shaw, and Martin beds west of the creek are mined from the Eska West tunnel, the Shaw, Eska, and Emery beds east of the creek from the Eska East tunnel, and the Maitland from the Maitland tunnel.

Prospecting on some coal beds which crop out about three-quarters of a mile west of Eska was postponed until spring on account of unfavorable weather.

A narrow-gage line extends 2,500 feet from the Eska West tunnel to the cleaning plant, which was installed in the fall of 1918. The coal passes over a $\frac{3}{4}$-inch grizzly; the undersize goes direct to the railroad cars and the oversize to the picking table, from which the waste is hand-picked and the lump passes to the same car as the undersize from the grizzly, or to a separate car as desired.

Besides the office and usual mine buildings a number of cottages have been put up on the Eska town site southeast of the mine workings for the use of the families and the office and technical force of the mine.

## GEOLOGY.

### STRATIGRAPHY.

The coal-bearing rocks at the Eska mine occur in an open syncline whose axis strikes across Eska Creek near the center of the mine camp. The coal beds have been identified on both limbs of the syncline and on both sides of the creek, which crosses the coal tract and divides it into two parts. Stratigraphically the coal beds occur in two groups of three beds each, separated by a thick interval of sandstone and shale. Although the coal and the inclosing sediments vary in character and thickness from place to place, the coal beds have prominent markers which are persistent enough to identify the beds with little doubt wherever they have been opened. The following stratigraphic section is generalized from data obtained on both limbs of the syncline on the west side of Eska Creek:

*Generalized section of coal measures at Eska.*

| | Feet. |
|---|---|
| Shale in trough of syncline; top concealed | 10 |
| Coal | 2 |
| Sandstone | 47 |
| Coal (Kelly bed) | 10 |
| Shale with a little sandstone | 38 |
| Coal (David bed) | 3½ |
| Shale, largely nodular | 52 |
| Coal (Emery bed) | 5½ |
| Sandstone and shale | 286 |
| Coal (Eska? bed) | 3 |
| Shale | 29 |
| Coal (Shaw bed) | 5 |
| Shale and ironstone | 11 |
| Coal (Martin bed) | 4½ |
| Shale with thin beds of coal | 100+ |

The thickness of the interval between the Emery and Eska beds is undetermined. This interval, where measured, is partly covered with slide, which possibly conceals faults. Where the bed doubtfully called the Eska crops out it is badly burned, so that its identity is not certain. It is believed to be the Eska, as it is the first exposed coal bed below the Emery and is evidently one of the lower group of coal beds. The interval between the upper and lower groups of beds is also concealed on the north limb of the syncline and on both limbs on the east side of the creek.

Above the coal beds that are being opened at the Eska and separated from them by an unknown interval of probably several hundred feet is another coal group containing several beds of coal.

The detailed section given below was measured along the south limb of the syncline on the west side of Eska Creek.

*Stratigraphic section of rocks exposed on south limb of syncline on west bank of Eska Creek.*

| | Ft. | in. |
|---|---|---|
| Shale in trough of syncline; top concealed | 10 | |
| Coal | 2 | |
| Gray sandstone | 32 | |
| Yellow sandstone | 15 | |
| Coal (Kelly bed) | 10 | |
| Shale | 19 | |
| Sandstone | 10 | |
| Gray nodular shale | 5 | |
| Shale | 4 | |
| Coal (David bed) | 3 | 6 |
| Carbonaceous shale | 6 | |
| Ironstone | | 3 |
| Carbonaceous shale | 1 | 2 |
| Gray shale | | 4 |
| Ironstone | | 6 |

| | Ft. | in. |
|---|---|---|
| Gray shale with ironstone nodules | 3 | 6 |
| Carbonaceous shale | | 6 |
| Gray shale with ironstone nodules | 18 | |
| Sandstone and shale | 5 | |
| Shale with ironstone nodules | 12 | |
| Shale with coal | 5 | |
| Coal (Emery bed) | 5 | 6 |
| Shale | 38 | |
| Shaly sandstone | 3 | |
| Thin-bedded sandstone | 10 | |
| Massive sandstone | 36 | |
| Carbonaceous shale with clay seam | 2 | |
| Shale with some sandy beds (partly concealed) | 40 | |
| Thin-bedded sandstone | 10 | |
| Massive sandstone | 32 | |
| Soft decomposed sandstone | 13 | |
| Carbonaceous shale | 1 | |
| Shale | 30 | |
| Concealed (probably shale) | 15 | |
| Shale | 46 | |
| Coal (Eska? bed) | 3 | |
| Shale. | | |

On the north limb of the syncline the beds of the upper part of the section are largely concealed on both sides of the creek. The following section of the cliff above the portal of the entry driven on the Eska West is adapted from notes of G. C. Martin:

*Section on cliff above Eska West entry.*

| | Ft. | in. |
|---|---|---|
| Sandstone (cliff) | 75 | |
| Soft sandstone | 9 | |
| Shale with a little coal | 2 | |
| Concealed shale and sandstone | 64 | |
| Shale | 16 | |
| Coal (Eska bed) | 3 | |
| Shale with coal streaks | 5 | |
| Shale | 14 | |
| Carbonaceous shale | 2 | |
| Shale and coal | 5 | |
| Coal (Shaw bed) | 5 | |
| Shale | 5 | |
| Ironstone | 1 | |
| Shale | 5 | |
| Coal (Martin bed) | 4 | 6 |
| Shale | 5 | |
| Coal | 2 | 2 |
| Shale with ironstone concretions | 23 | |

Above the sandstone that makes the cliff is a concealed interval, which from its wash is judged to contain both shale and sandstone. The Emery bed is probably at about this horizon but does not crop out. As shown later, there is reason to believe that at this place it

may be cut out by faulting. Above this concealed interval the David and Kelly beds are exposed but are too crushed and burned on the surface to give a good idea of their character.

Below this section is 25 feet of alternating thin beds of coal and shale overlying about 80 feet of shale and ironstone carrying a few thin coal beds. None of these appear to be worth opening up, as the beds are thin and are considerably broken by faulting.

On the east side of Eska Creek the coal beds on the north limb of the syncline have been correlated with the known beds on the other side of the creek. The equivalent of the Kelly bed on this side of the creek, however, is known as the Maitland. This naming was used before the identity of the beds was established and is still retained. On the south limb of the syncline on the east side of Eska Creek the rocks on the hillside are largely concealed, but coal beds have been opened which correspond in position and character to the Maitland, David, and Emery. Beds also occur which occupy about the position of the Eska, Shaw, and Martin, so it appears that the section exposed across Eska Creek is present here also.

It is evident, however, that the inclosing rocks vary greatly from place to place along the strike. Above the Eska West bed on the north limb of the syncline there is a section containing a stratigraphic thickness of 165 feet (and possibly much more in the concealed interval) of sandstone with very little shale. Whether or not the burned bed of coal on the sharp curve of the high line is correctly correlated as the Eska bed, the fact remains that on the south limb of the syncline the reverse is true and shale predominates. This, however, may be due in part to undetected faulting in the concealed part on either or both limbs of the syncline. Sandstone also seems to be less abundant on the east side of the creek than on the west side. The sandstone that overlies the Kelly bed on the west side of Eska Creek has a stratigraphic thickness of 47 feet, and the corresponding member above the Maitland is only about 25 feet thick.

The massive sandstone that makes up the cliff above the Eska West entry does not appear on the east side of the creek in a corresponding stratigraphic position. This absence, however, is due, at least in part, to faulting. On the south limb of the syncline also there appears to be less sandstone than in the corresponding members on the west side of the creek, but here, as in other places, this may be due partly to faulting.

The stratigraphic position of these coal-bearing beds in the Chickaloon formation is not certain. Beneath the coal beds of the Eska mine there is at least 200 feet of sedimentary rock and possibly many times as much. The base of the Chickaloon formation is not exposed in this vicinity, and the nature of its contact with the underlying Cretaceous rocks is not known. The coal outcrops recently found

three-quarters of a mile west of Eska are evidently much higher stratigraphically and apparently are near the base of the Eska conglomerate of Wishbone Hill. This horizon may correspond to that of the coal-bearing rocks at the Baxter mine on Moose Creek.

### THE COAL BEDS.

*Martin bed.*—The Martin bed is about 4½ feet thick and is made up of two benches with a thick parting of shale. An underlying bed of coal, 2 feet thick, is separated from the Martin bed by 5 feet of shale.

*Section of the Martin bed in the Martin West tunnel.*

| | Ft. | in. |
|---|---|---|
| Hanging wall, carbonaceous shale. | | |
| Coal | 2 | |
| Shale | 1 | 1 |
| Coal | 1 | 5 |
| Footwall, shale. | | |

*Shaw bed.*—The Shaw bed is from 4 to 5 feet thick and is characterized by three very distinct markers of yellow clay and shale.

*Section of Shaw bed in room 5, Shaw West tunnel.*

| | Ft. | in. |
|---|---|---|
| Hanging wall, shale. | | |
| Coal | | 10 |
| Shale | | 2 |
| Coal | | 8 |
| Sandy shale | | 1 |
| Coal | | 8 |
| Shale | | 1 |
| Coal | 2 | |
| Footwall, shale. | | |

*Section of Shaw bed in Shaw East tunnel.*

| | Ft. | in. |
|---|---|---|
| Hanging wall, carbonaceous shale and bone. | | |
| Coal | 1 | 2 |
| Shale parting | | 1 |
| Coal | 1 | |
| Shale | | 2 |
| Coal | | 7 |
| Shale | | 5 |
| Coal and bone | 1 | 10 |
| Footwall, shale. | | |

*Eska bed.*—The Eska bed ranges in thickness from 2½ to 3 feet and is underlain by 5 feet of carbonaceous shale. Above the coal is 6 inches or more of carbonaceous shale with a very characteristic clay marker.

*Section of Eska bed in Eska West tunnel.*

| | Ft. | in. |
|---|---|---|
| Hanging wall, carbonaceous shale with clay marker | | 6+ |
| Coal | 3 | |
| Bone and carbonaceous shale | 5 | |
| Footwall, shale. | | |

*Section of Eska bed in Eska East tunnel.*[1]

| | Ft. | in. |
|---|---|---|
| Hanging wall, shale. | | |
| Shale and bone | | 7 |
| Coal, woody structure, with thin sulphur bands | | 9 |
| Compact shale marker | | 1 |
| Medium-hard black coal, woody structure | | 8 |
| Parting. | | |
| Coal | | 1 |
| Coal, woody structure, with bone and sulphur bands | 2 | |
| Footwall, shale. | | |

*Emery bed.*—The Emery bed contains from 4 to 5½ feet of coal, with some bone and shale. The part which is being extracted in mining is from 2½ to 4 feet thick and averages about 3 feet.

*Section of Emery bed at face of Shaw East tunnel.*

| | Ft. | in. |
|---|---|---|
| Hanging wall, shale. | | |
| Coal | 1 | |
| Bone and coaly shale | | 10 |
| Clay | | 2 |
| Coal and shale | | 6 |
| Coal | 1 | 5 |
| Parting. | | |
| Coal | 1 | 6 |
| Footwall, carbonaceous shale. | | |

*Section of Emery bed on west bank of Eska Creek.*

| | Ft. | in. |
|---|---|---|
| Hanging wall, shale and coal. | | |
| Coal | | 11 |
| Shale | | 1 |
| Coal | | 5 |
| Soft shale | | 1 |
| Coal | 2 | 6 |
| Shale | | 1 |
| Coal | 1 | |

*David bed.*—The David bed is from 2½ to 3 feet thick. It has two benches of coal with a thin marker of yellow shale.

*Section of David bed on west bank of Eska Creek.*[2]

| | Ft. | in. |
|---|---|---|
| Hanging wall, shale. | | |
| Coal | 2 | 6 |
| Yellow shale | | 1½ |
| Coal | | 10 |

[1] Smith, S. S., Alaskan Engineering Commission, Mining Dept., Report for year ending Dec. 31, 1917.

[2] Martin, G. C., Geologic problems at the Matanuska coal mines: U. S. Geol. Survey Bull. 692, p. 271, 1919.

*Section of David bed in David airway.*[1]

| | Ft. | in. |
|---|---|---|
| Hanging wall, compact shale. | | |
| Clod and shale with streaks of coal | | 11 |
| Niggerhead | | 1½–2 |
| Hard black friable coal, well-developed cleat | 1 | 10 |
| Bone | | 2 |
| Footwall, shale. | | |

*Kelly bed.*—The Kelly bed contains a lower bench, a thick parting of bony coal and shale, and an upper bench, which average, respectively, 3, 5, and 2 feet in thickness.

*Maitland bed.*—The Kelly bed is known on the east side of Eska Creek as the Maitland bed. The lower bench, from which coal has been mined, is from 2½ to 4 feet thick and averages about 3 feet. The following section was measured by Sumner S. Smith:

*Section of Maitland bed in Maitland tunnel.*

| | Ft. | in. |
|---|---|---|
| Hanging wall, compact shale and sandstone. | | |
| Soft shale with streaks of coal | | 3 |
| Compact brown shale marker | | ¾ |
| Black friable coal | 1 to 2 | 6 to 2 |
| Bone, coal, and clod | | 4–7 |
| Black friable coal | 2 to 3 | 6 to 6 |
| Bone | | 2 |
| Footwall. | | |

*Coal beds west of Eska mine.*—About three-quarters of a mile west of the Eska mine some coal beds are being prospected. Two open cuts show the following sections:

*Section on tributary of Eska Creek three-quarters of a mile west of Eska mine.*

| | Ft. | in. |
|---|---|---|
| Coal with three shale partings | 7 | |
| Carbonaceous shale | 2 | 6 |
| Coal | 3 | |
| Concealed interval. | | |
| Shale | 3 | |
| Coaly shale | 2 | |
| Coal | 1 | 10 |
| Parting | | 4 |
| Coal (dirty) | 2 | 4 |
| Shale | | 7 |
| Coal | | 4 |

[1] Smith, S. S., Alaskan Engineering Commission, Mining Dept., Report for year ending Dec. 31, 1917.

| | Ft. | in. |
|---|---|---|
| Carbonaceous shale | 1 | 6 |
| Coal | | 6 |
| Coaly shale | | 6 |
| Shale | | 6 |
| Coal | | 10 |
| Shale | | 4 |
| Coal | 1 | |
| Coaly shale | 3 | |

## STRUCTURE.

The coal-bearing rocks at the Eska mine lie in an open syncline whose axis trends across Eska Creek with a strike of about N. 60° E. and pitches slightly southwest. East of the creek the trough of the syncline is very open, and the rocks of the north limb are flat lying. The south limb is largely obscured by débris. On the west side of the creek the open folding of the syncline is somewhat disturbed on the north flank by faulting, which has thrown the Kelly and David coal beds and the adjacent strata into a steep attitude. This axis lies almost in line with the synclinal axis of Wishbone Hill and may be on the same fold. Structure sections are shown in figure 3.

Faulting is very evident in this coal tract. The rocks bordering Eska Creek appear to be in a downthrown block, which itself is broken by faults striking at various angles, as opposed to the orderly and parallel arrangement of the main faults at Chickaloon. The tract now being mined is bounded on the north by a fault zone, beyond which the ground is broken, and it is doubtful whether mining could be carried on profitably. The coal-bearing area is probably limited on the east also by a fault, which is not known to exist but which is predicated to explain the absence of the Tertiary arkose beds between the Chickaloon formation and the Cretaceous rocks east of Eska Creek. To account for this it seems necessary to accept the existence of a fault of considerable dislocation and a relative downward movement of the block west of the fault. Within the coal tract there is not a coal bed now being opened that has not been faulted. Most of the faults encountered, however, are not great, and as a rule the faulted part has been found without much difficulty.

At 280 feet from the mouth of the Eska West tunnel a fault has offset the Eska bed toward the south for a horizontal distance of 50 feet and brought the faulted ends of the Shaw and Eska beds together, so that the entry passes from one bed to another without any perceptible break. About 180 feet west of this point a parallel fault has brought the Shaw and Martin beds together in a similar manner. The horizontal displacement along the eastern fault is 50 feet, and that along the western fault is 60 feet. Near the face of the Eska West tunnel a fault striking northwest cuts the coal bed. The

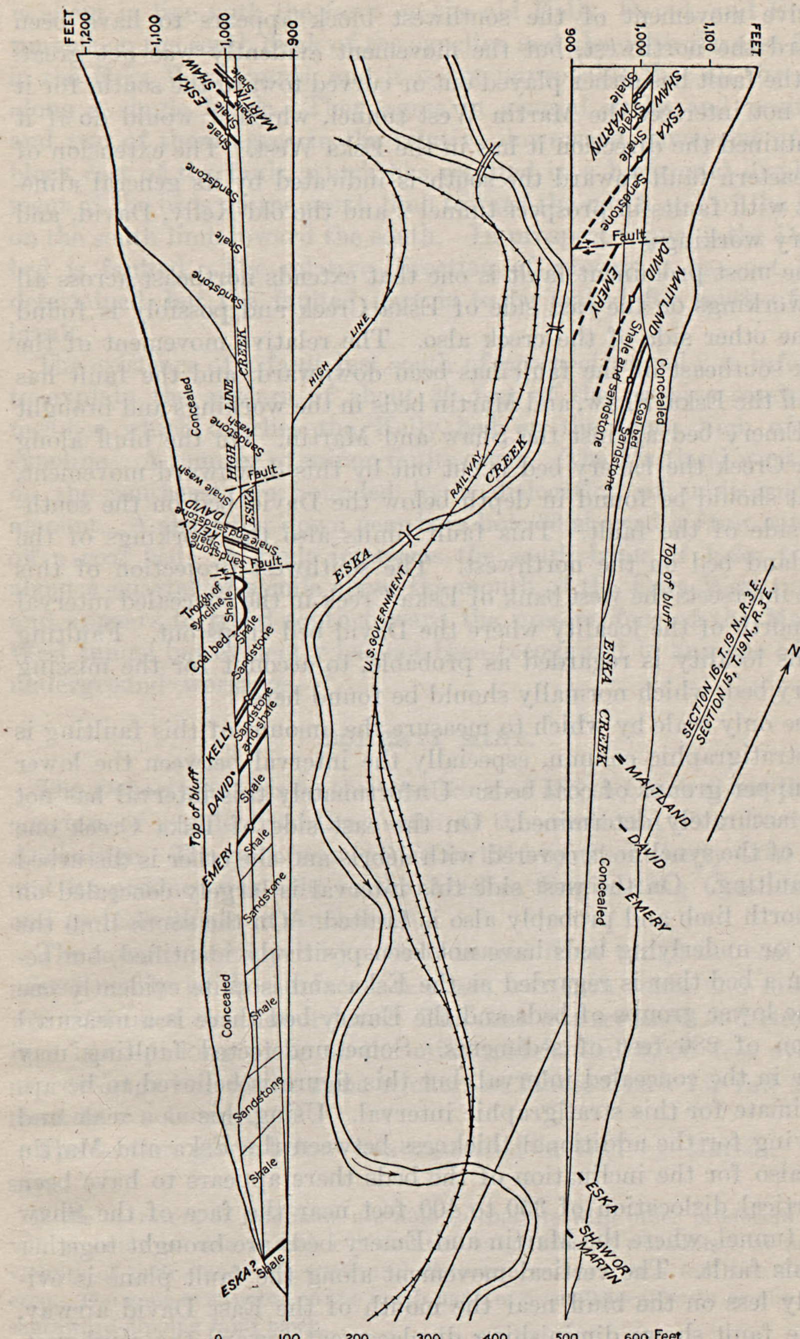



FIGURE 3.—Structure sections at Eska coal mine.

relative movement of the southwest block appears to have been toward the northwest, but the movement evidently was not great, and the fault has either played out or curved toward the south, for it does not intersect the Martin West tunnel, which it would do if it maintained the direction it has in the Eska West. The extension of the eastern fault toward the south is indicated by its general alinement with faults in prospect tunnel 2 and the old Kelly, David, and Emery workings.

The most prominent fault is one that extends northeast across all the workings on the east side of Eska Creek and possibly is found on the other side of the creek also. The relative movement of the block southeast of the fault has been downward, and the fault has cut off the Eska, Shaw, and Martin beds in the workings and brought the Emery bed against the Shaw and Martin. On the bluff along Eska Creek the Emery bed is cut out by this downward movement, but it should be found in depth below the David bed on the southeast side of the fault. This fault limits also the workings of the Maitland bed on the northwest. The southwest projection of this fault intersects the west bank of Eska Creek in the concealed interval just north of the locality where the David bed crops out. Faulting at this locality is regarded as probable, to account for the missing Emery bed, which normally should be found here.

The only scale by which to measure the amount of this faulting is the stratigraphic column, especially the interval between the lower and upper groups of coal beds. Unfortunately this interval has not been accurately determined. On the east side of Eska Creek one limb of the syncline is covered with débris and the other is disturbed by faulting. On the west side this interval is largely concealed on the north limb and probably also is faulted. On the south limb the Eska or underlying beds have not been positively identified, but between a bed that is regarded as the Eska and is quite evidently one of the lower groups of beds and the Emery bed there is a measured section of 286 feet of sediments. Some undetected faulting may occur in the concealed interval, but this figure is believed to be approximate for this stratigraphic interval. Using this as a scale and allowing for the additional thickness between the Eska and Martin and also for the inclination of the beds there appears to have been a vertical dislocation of 350 to 400 feet near the face of the Shaw East tunnel, where the Martin and Emery beds are brought together by this fault. The vertical movement along the fault plane is evidently less on the bluff near the mouth of the East David airway, as the fault shows diminishing displacement toward the southwest.

Just south of this locality a fault that crosses prospect tunnel 2, which is now being driven to open up the David and Emery beds,

is about in line with the fault on the old Kelly, David, and Emery tunnels on the south flank of the syncline and also with the east fault in the Eska West tunnel, and it is not improbable that all three lie along a single break. They agree in general strike and position, and two of them agree in the relative downward movement of the block east of the fault, which has resulted in a horizontal displacement of the beds on the north limb toward the north and of the beds on the south limb toward the south. In prospect tunnel 2 the David bed is faulted. The relative direction of movement has not been determined, but the faulted part is to be looked for south of the break.

The existence of a fault just south of prospect tunnel 2 is inferred to explain the absence of about 30 feet of the massive sandstone member which overlies the Kelly bed on the south limb of the syncline. A number of minor faults occur. The Maitland workings on the southeast are bounded by a dislocation of undetermined amount. A shaft put down near bore hole 33 showed a fault cutting off a coal bed. A fault intersects the south bank of Eska Creek about a quarter of a mile above the mouth of the Eska West tunnel and appears to trend south toward the present face of the Martin West tunnel but evidently has not been recognized in any one of the underground workings.

## DOHERTY MINE.

The Doherty mine is on the west bank of Moose Creek about three-quarters of a mile from the mouth of the creek and 50 miles from Anchorage. The mine was opened in 1916 by the Doherty Coal Co., and its product was sold to the Alaskan Engineering Commission and to individuals in Anchorage.

The mine is developed by a drift tunnel from which the coal was mined nearly to the surface. A shaft was then sunk, and mining was continued on a lower level. The coal was screened and cleaned in a hand-picking plant at the mine and hauled 3,000 feet over a narrow-gage line to the mine bunkers at Moose Creek for rail shipment to Anchorage.

The section given below was measured in 1917 by Martin,[1] who says:

> If the operators of this mine are able to compete with other producers they will probably be able to find a moderately large area of workable coal in the vicinity of their mine. No structural disturbances have thus far been discovered. The mine is situated on the north flank of a small local basin or else on a southward-dipping fault block.

[1] Martin, G. C., Geologic problems at the Matanuska coal mines: U. S. Geol. Survey Bull. 692, p. 282, 1919.

*Section of coal in Doherty mine.*

| | Ft. | in. |
|---|---|---|
| Sandstone (roof). | | |
| Bone ("cap rock") | 1 | 1 |
| Coal | 1 | 11 |
| Bone | | 1 |
| Coal | 1 | 3 |
| Carbonaceous shale ("black dirt") | | 3 |
| Shale (floor). | | |
| Strike N. 67° E., dip 45° SE. | | |

The coal shipped from this mine was of low grade on account of the high ash content resulting from the lack of adequate cleaning, and it never proved to be satisfactory. No coal was mined here in 1918.

### BAXTER MINE.

The Baxter mine is on Moose Creek about 4½ miles from Moose Creek station, on the Matanuska branch of the railroad. The mine is on a tract comprising leasing units 2 and 3, the lease for which was granted to Oliver La Duke, Henry Baxter, C. C. Harcy, and W. A. Smith early in 1917. Mining operations began in December, 1917, and continued until April, 1918, as long as it was possible to sled the coal to the railroad at Moose Creek. The output was sold in the local market and to the Alaskan Engineering Commission. A little development work was continued during a part of the summer of 1918, but the mine remained idle the rest of the year. The coal-bearing rocks crop out on the east bank of Moose Creek on a prominent bluff on which the coal is exposed for several hundred feet. The most conspicuous bed, known as the "big bed," is 11 feet thick and occurs in two benches 4 and 7 feet thick with a shale parting of 2 inches. Aside from this shale parting the bed is comparatively free from impurities, and the coal has proved to be very popular for domestic use. The mine was opened with the hope of making an immediate production, and the size and purity of the "big bed" offered such promising possibilities of maintaining a considerable tonnage from the start of mining operations that the difficulties of mining it, due to unfavorable structural features, were not properly taken into account.

That the rocks exposed along Moose Creek are faulted and not in place is evident from their broken appearance and the detached blocks of coal, and from the discordance between their dip and strike and the attitude which would be normal along this limb of the Wishbone Hill syncline, and even from the discordance between the creek exposures from place to place.

The mine is being developed by three tunnels driven into the bluff to open up the "big bed." (See fig. 4.) Tunnel 1 is about 300 feet long. In places it cuts across the formation, and in places it drifts along coal beds in an attempt to prospect the broken ground.

It is connected by a number of workings with an upper level 40 feet higher, which comes to the surface at the air shaft. Tunnel 1 cuts diagonally across the strike of the beds for 40 feet and then cuts

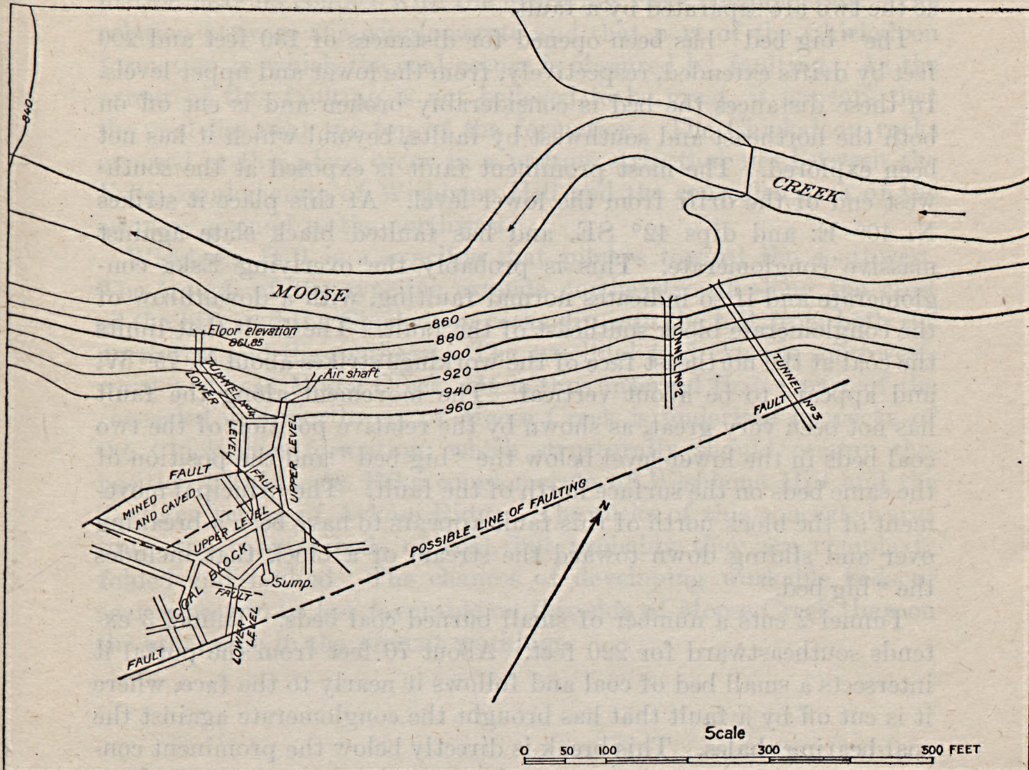



FIGURE 4.—Map of Baxter mine showing faults.

a coal bed, which is opened by a drift for 95 feet to a fault that cuts the coal off. From this point the tunnel again cuts diagonally across the strike of the formation for 170 feet and intersects two small beds of coal and the "big bed" for which the mine is being developed. The following section is exposed:

*Section of coal-bearing rocks cut in tunnel 1, Baxter mine, Moose Creek.*

| | | Ft. | in. |
|---|---|---|---|
| Shale, hanging wall. | | | |
| Coal ("big bed") | Coal | 4 | |
| | Shale | | 2 |
| | Coal | 7 | |
| Shale | | 14 | |
| Coal | | 3 | |
| Bone | | 1 | |
| Shale | | 2 | 8 |
| Bone | | 1 | 6 |
| Coal | | 2 | 6 |
| Bony coal | | 2 | 6 |
| Shale, footwall. | | | |

These same beds are exposed along the stream a short distance northeast of the entry. The relation of the small bed of coal exposed near the mouth of the tunnel to the section given above is not known, as the two are separated by a fault.

The "big bed" has been opened for distances of 130 feet and 200 feet by drifts extended, respectively, from the lower and upper levels. In these distances the bed is considerably broken and is cut off on both the northeast and southwest by faults, beyond which it has not been explored. The most prominent fault is exposed at the southwest end of the drift from the lower level. At this place it strikes N. 40° E. and dips 42° SE. and has faulted black slate against massive conglomerate. This is probably the overlying Eska conglomerate and if so indicates normal faulting, with a downthrow of the conglomerate block southeast of the fault. The fault that limits the coal at the northeast face of the workings strikes about N. 75° W. and appears to be about vertical. The movement along the fault has not been very great, as shown by the relative position of the two coal beds in the lower level below the "big bed" and the position of the same beds on the surface north of the fault. The principal movement of the block north of this fault appears to have been a breaking over and sliding down toward the stream of a block that includes the "big bed."

Tunnel 2 cuts a number of small burned coal beds. Tunnel 3 extends southeastward for 220 feet. About 70 feet from the portal it intersects a small bed of coal and follows it nearly to the face, where it is cut off by a fault that has brought the conglomerate against the coal-bearing shales. This break is directly below the prominent conglomerate cliff, suggestive of a fault scarp, that caps the bluff above the river, and it also lies on the northwesterly projection of the line of faulting in the southwest end of the workings in tunnel 1, where conglomerate is faulted downward against shale. These facts suggest that the two breaks may be on the same line of dislocation. The conglomerate at both places relatively moved downward and carried the coal-bearing beds downward also.

To prospect for the coal-bearing rocks it will be necessary to extend the workings downward along the fault the amount of the normal displacement along this plane. The amount of this movement has not been determined or even estimated, as there appear to be no data on which to base an estimate. It will have to be determined by actual exploration.

The location of this bed southeast of the fault is not believed to be an unsurmountable difficulty, or one which should discourage the active development of the mine. The amount of displacement may be several hundred feet, but southeast of the line of faulting, beneath the massive conglomerate, the rocks, including the coal-bearing

strata, are probably much less fractured than those exposed by the present workings.

The coal-bearing rocks at this mine lie within the Chickaloon formation near its contact with the overlying Eska conglomerate. The relation between the conglomerate and that part of the Chickaloon formation in which the coal occurs is obscured by faulting. As the extent of this faulting is not believed to be great, it appears that the coal lies near the top of the formation. The Chickaloon rocks exposed at this place occur in a narrow strip that lies between the Eska conglomerate of Wishbone Hill and the concealed area of the swampy ground to the northwest.

Wishbone Hill is a syncline that pitches toward the southwest. The trough of the syncline extends northeastward along the crest of the hill, and the Chickaloon rocks dip into the hill from both the northwest and the southeast. The synclinal fold extends southwestward as far as Moose Creek. It is thus inferred that a part of the concealed area northwest of Moose Creek is underlain by rocks of the Chickaloon formation, which structurally should occupy this position between the Eska conglomerate of Wishbone Hill and the Tertiary arkose of Arkose Ridge. The rocks of this concealed area thus may contain beds of coal, but probably they are complexly folded and faulted. The chances of developing workable beds of coal appear to be less favorable on this side of Moose Creek than on the other side in the present workings.

# LODE DEVELOPMENTS IN THE WILLOW CREEK DISTRICT.

By Theodore Chapin.

## INTRODUCTION.

The region popularly known as the Willow Creek mining district comprises an area of about 40 square miles in the Talkeetna Mountains and is about 12 miles from the head of Knik Arm, one of the branches of Cook Inlet. The region is tributary to both Susitna and Little Susitna rivers and takes its name from Willow Creek, one of the principal streams of the area, although none of the productive lode properties are on Willow Creek itself.

This paper on the recent developments is based on a few days' work in September, 1918, in which the producing properties were hurriedly visited incidentally to the collection of data on mineral production.[1] An early fall of snow prevented the examination of surface prospects which otherwise would have been visited. No attempt is here made to describe all the mines and prospects in the district, only those where production has been maintained being mentioned. The location of the mines and prospects is shown on figure 5.

The Survey is indebted to many persons for information used in this report, especially to Messrs. N. D. Bothwell, James McDonald, B. Pinder, W. R. Hocking, W. S. Horning, W. P. Martin, Charles Bartholf, Henry Emard, Sam McMelan, Theodore Pilger, and Milo Kelly.

The Willow Creek district may be reached by wagon road from Wasilla, a station on the Government railroad 16 miles from the Fishhook Inn, on the edge of the Willow Creek district, and 55 miles from Anchorage. It may also be reached by a slightly shorter route by trail from Moose Creek, a station on the Matanuska branch of the railroad.

The Willow Creek district is being exploited for its gold lodes, which occur as fissure veins in quartz diorite. The geologic features are favorable for depth of veins and permanence of gold content.

[1] For a detailed description of the district and reports of progress of mining see Capps, S. R., The Willow Creek district, Alaska: U. S. Geol. Survey Bull. 607, 1915; also U. S. Geol. Survey Bull. 642, p. 195, 1916, and Bull. 692, p. 177, 1919.

The region has not received the attention of prospectors or investors that the geologic conditions would seem to justify, however, and development has been retarded by a number of adverse conditions, some of which have lately been partly overcome and others, it is hoped, will be improved in the near future. At present the outlook is bright for a continued development of the region and a permanent camp with increased production.

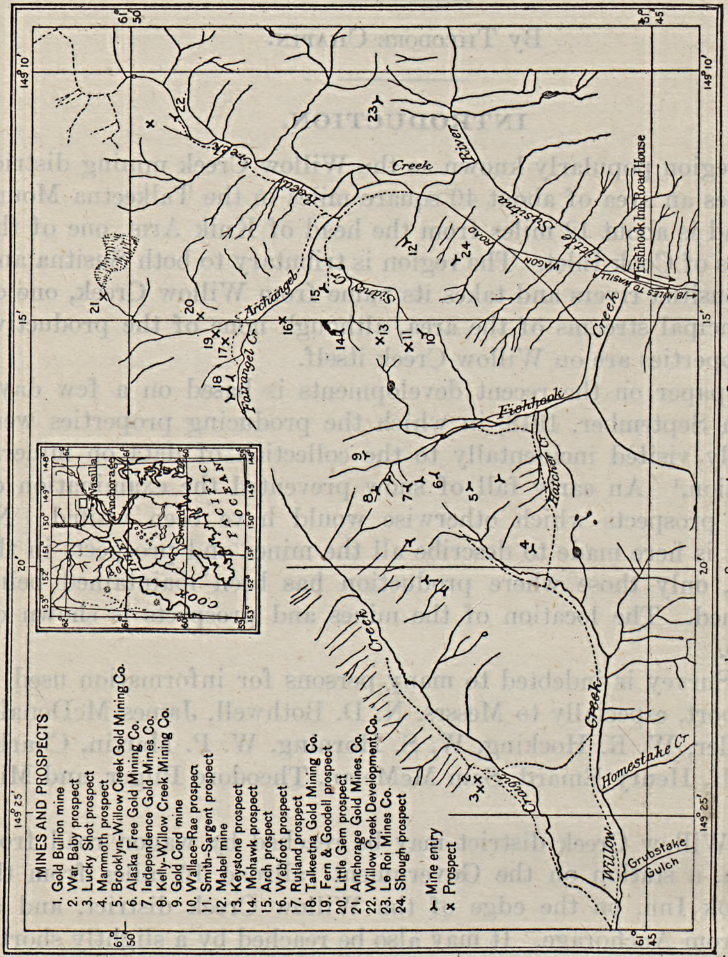



FIGURE 5.—Map of Willow Creek district showing location of mines and prospects.

The high cost of transportation to the mines, caused by the remoteness of the region, has been somewhat reduced by the construction of the Government railroad. Previous to its operation supplies were brought from Knik, a distance of about 31 to 35 miles. Machinery and supplies are now sledded in during the winter from Houston and freighted by team and motor truck during the summer from Wasilla, both stations on the railroad. The winter freight rate

from Houston is 2½ cents a pound, and the summer rate from Wasilla ranges from 1½ to 2½ cents.

One of the main obstacles to successful mining in this district is the short operating season—three to five months. This is governed mainly by the period during which it is possible to obtain power for milling. Power used at the mills is derived principally from water-driven Pelton wheels and turbines and is usually generated at the point of utilization. The water supply is drawn from near-by small streams, lakes, or artificial reservoirs, which are frozen or considerably diminished in flow from about September to May. Dependence on this source of power necessarily limits the operation of the mills to the short open season of 90 to 130 days and imposes a heavy duty on the investment. The development of cheap electric energy for winter use is an imperative need of the district. To supply this need a hydro-electric power plant on Little Susitna River or in the canyon of Willow Creek has often been suggested. A plan which seems more feasible is the erection of a central power plant near some supply of coal. An efficient plant might be one designed to utilize the producer-gas principle, which involves the complete gasification of the coal, with or without the recovery of the by-products (tar, ammonium sulphate, and light oil), and a resulting carbon residue suitable for fuel. With such a plant, which could utilize lignite or even high-ash mine refuse, the gas evolved could be used directly for fuel in the generation of electric energy for transmission to the mines. The carbonaceous residue resulting from the gasification of the coal is convertible into briquets of smokeless fuel, probably of higher grade than any coal now locally used in Anchorage. The recoverable by-products that might be used locally are tar for road dressing, ammonium sulphate for fertilizer, and benzol, a product of the light oil, for motor oil. Other by-products are dyes, various useful chemicals, and toluol, which is essential in the manufacture of high explosives.

Another urgent need of the district is the consolidation of some of the smaller properties, which to date have had a struggling existence but might be run at a profit by the reduction of overhead expenses and the advantage of efficient management and technical advice, which have been sadly lacking in the past at many of the properties.

## MINING IN 1918.

Mining in the Willow Creek district in 1918 was conducted on about the same scale as during the previous year. Five mines were operated and yielded $269,624 worth of gold and $724 worth of silver. The lodes of this district have produced to date gold to the value of $1,602,380, as shown in the subjoined table.

*Gold and silver produced at lode mines in Willow Creek district, 1908–1918.*

| Year. | Gold. | | Silver. | |
|---|---|---|---|---|
| | Quantity (ounces). | Value. | Quantity (ounces). | Value. |
| 1908 | 87.08 | $1,800 | 6.88 | $3.64 |
| 1909 | 1,015.87 | 21,000 | 80.25 | 41.73 |
| 1910 | 1,320.15 | 21,290 | 104.29 | 56.31 |
| 1911 | 2,505.82 | 51,800 | 197.95 | 109.91 |
| 1912 | 4,673.02 | 96,600 | 369.07 | 226.97 |
| 1913 | 4,883.94 | 100,960 | 385.83 | 233.42 |
| 1914 | 14,376.28 | 297,184 | 1,330.00 | 735.00 |
| 1915 | 11,961.55 | 247,267 | 811.00 | 421.00 |
| 1916 | 14,473.46 | 299,193 | 1,468.00 | 967.00 |
| 1917 | 9,466.17 | 195,662 | 713.00 | 586.00 |
| 1918 | 13,043.05 | 269,624 | 724.00 | 724.00 |
| | 77,806.39 | 1,602,380 | 6,190.27 | 4,104.98 |

During the summer of 1918 a great deal of interest was manifested in the district, several sales of mining property were recorded, a great number of examinations were made by mining men, a mill was in process of erection on one of the properties, and a new mining company was incorporated in Anchorage.

Interest was further stimulated by the reported discovery of platinum in the gold lodes. Samples collected by the writer from two of the mines were submitted to the Geological Survey for assay, but no platinum was found. This result is not surprising, as the geologic associations of the Willow Creek lodes do not favor the occurrence of platinum, which although found in siliceous lodes in small quantities is usually restricted to magnesian plutonic rocks, especially the more basic rocks, such as dunite and pyroxenite. The only known basic intrusive rocks in this district are some gabbros that cut the granites in the eastern part of the district. These are green rocks found as local patches in the granite. None of the reported platinum-bearing ores come from these rocks, nor is there any evidence that they carry platinum.

## LODES.

The Willow Creek mining district is being developed mainly for gold, which occurs in fissure veins in quartz diorite and related rocks that are intrusive into mica schist. The gold occurs mainly as free gold in a quartz gangue, which also carries various sulphides. About 90 per cent of the gold obtained is recovered by amalgamation and the remainder by cyanidation of the sands and tailings.

The hard-rock formation of the Willow Creek district are mica schist and chlorite-albite schist cut by granitic rocks, mainly quartz diorite, and overlain by arkose, shale, conglomerate, and sandstone. The quartz diorite is intrusive into the mica schist, but both schist and diorite are unconformably overlain by the arenaceous sediments. The granitic rocks are provisionally correlated with the Coast Range intrusive rocks and in this general region are probably of Lower or

Middle Jurassic age. The mica schist is thus Jurassic or earlier and is probably much older. The arenaceous sediments are of Eocene age and therefore have not shared in the mineralization, which is believed to be genetically related to the invasion of the mica schist by the quartz diorite.

The proved productive zone is in the intrusive rock, which thus appears to be the best ground for future prospecting. The sandstone and associated sediments were deposited later than the mineralization of the granitic rocks and evidently do not carry any valuable metallic deposits.

## MINES AND PROSPECTS.

### GOLD BULLION MINE.

The Gold Bullion mine, the most constant producer in the district, is operated by the Willow Creek Mines. The mine is at an elevation of 4,500 feet on the divide between Craigie and Willow creeks, and the mill is on Craigie Creek 1,500 feet below the mine.

The mine is developed on a single vein that follows a very persistent fissure, which strikes about S. 10° W. and dips 14° NW. The vein filling, however, is less regular and in some places pinches to a mere stringer and in others splits up into three veins. The vein is broken by three main faults, which strike from S. 10° E. to S. 30° E. and dip 40°–55° NE. These faults have produced normal step faulting of small displacement.

The principal developments of 1918 were the driving of a raise southeastward to connect with the old Gold Dust workings and a drift southwestward toward the old Nos. 3, 4, and 5 tunnels on the Golden Wonder and Golden Wonder No. 1. About 53 tons of ore mined on the Gold Dust No. 1 claim was taken from an ore body known as the Pass vein but probably a faulted portion of the main vein. This ore was taken to the mill by pack horses.

The ore from the mine is transported to the mill by aerial tram. The mill is equipped with three batteries containing 13 stamps of 1,000 and 1,050 pounds each, amalgamating plates, classifiers, and a 30-ton cyanide plant. The mill operates three shifts a day and handles 50 tons in 24 hours. The plant is driven by power generated by a Pelton wheel and turbine.

The Willow Creek Mines have taken an option on the Lucky Shot and Panhandle groups now under development and plan to operate these next year.

### WAR BABY PROSPECT.

The War Baby prospect consists of four claims, known as the War Baby Nos. 1, 2, 3, and 4, on Craigie Creek at an elevation of about 3,000 feet and 2 miles from the mouth of the creek. The property

was located in 1918 and is now being developed by W. S. Horning, C. A. Bartholf, David Miller, and W. T. Rock.

Surface stripping has exposed a mineralized zone about 33 feet across containing four or five parallel quartz veins that strike N. 80° E. and dip 17°–62° NW. The footwall of the lode is altered granite with 9 inches of quartz. Above this through an interval of over 30 feet are three quartz veins from 1 to 5 inches thick cutting quartz diorite. The hanging wall of the lode appears to be a red-stained fissure parallel to the quartz veins and dipping steeply northwest toward the canyon wall. About 600 feet to the southwest what appears to be the same lode is exposed. At this place a lode from 3 to 4 feet thick carries a quartz vein 15 inches thick and stringers of quartz in altered granite.

The ground is being developed by a tunnel which is expected to intersect the vein 100 feet from the mouth. A Straub well equipped with 10 stamps of 250 pounds each is in course of construction. The mill will be run by a gasoline engine and will be used for prospecting the ore and making small mill runs until the output necessitates a mill of greater capacity.

### PANHANDLE AND LUCKY SHOT PROSPECTS.

The Panhandle and Lucky Shot groups of claims are being developed just west of the War Baby claims on what appears to be the same vein as the War Baby lode. These two groups of claims are said to cover the outcrops of two parallel veins striking about east and a third vein striking N. 60° W. and crossing the other two. Development work was begun on these claims in 1918, and some surface openings were made preparatory to underground operations. The Willow Creek Mines now have an option on this property and plan to operate it next season.

### ALASKA FREE GOLD MINING CO.'S MINE.

The mine of the Alaska Free Gold Mining Co. is on Fishhook Creek at an elevation of about 4,300 feet. It is now operated on a lease to W. P. Martin, who continued development work and milling during a part of the season of 1918. The principal development work has been done on the Skyscraper vein, on which nine tunnels have been driven with an aggregate length of over 2,300 feet, besides connecting winzes and stopes. The ore from the mine is lowered by aerial tramway to the mill, which is equipped with two Chilean mills of 40-ton capacity. The tailings are treated in a cyanide plant.

### GOLD CORD MINE.

The Gold Cord mine is on the east side of Craigie Creek near its head, at an elevation of about 4,100 feet. This property was located

in 1915, and some development work was done. A mill test on 100 tons of ore made last year is said to have proved satisfactory, and the property was sold to J. H. Smith and Joseph Swan. During 1918 the property was further developed by W. P. Martin under a lease from the owners.

The developments on the Gold Cord at the end of the working season of 1918 consisted of about 500 feet of tunnel, a crosscut, two small stopes, and an open cut on the lode. The lode strikes N. 10° W. and dips 30°–65° SW., with an average dip of about 40°. The ore body differs somewhat from the typical veins of the region. It is a stringer lode composed of reticulating veins of quartz which penetrate the quartz diorite country rock, forming a lode that in places is 13 feet wide. The tunnel is driven along the lode but does not open its entire width except where the lode is narrowed by pinching or faulting or where a crosscut or a stope has been extended. The lode has formed on a prominent joint plane, along which faulting has later taken place and evidently pinched the vein. The hanging wall is well defined. The footwall is less definite and is marked by a number of parallel planes along each of which the ore appears to terminate abruptly.

The quartz diorite included within the quartz veins is altered and mineralized with sulphides, but the gold content has not been determined.

## MABEL MINE.

The Mabel mine is on the west side of the valley of Little Susitna River, on a small tributary of Reed Creek. The vein has been exposed on the surface for a claim length by short tunnels and open cuts. The vein strikes about north and dips west at a low angle. The mine is being developed by two parallel tunnels known as tunnels 2 and 3, driven northwestward to intersect the vein. The principal work has been done on tunnel 2, which follows a joint plane. About 20 feet from the mouth the tunnel encountered a fault striking north to northwest and dipping 45°–60° W. A drift extended northward along this fault plane exposed the quartz vein abutting against it. The portion of this vein extending from this fault to the surface has been stoped out and milled for a part of the distance between the two tunnels. At the face of tunnel 2 a short drift was turned off to the north and a much longer one to the south, following the intersection of another fault and quartz vein. Both strike about N. 30° E. and dip northwest. The quartz vein dips 30°, but the fault is much steeper and exposes the quartz vein in the northwest wall of the drift. The quartz here is as a whole of rather low grade but carries stringers of very rich ore.

Tunnel 3 extends northwestward about parallel to tunnel 2. Near the face a flat-lying vein of quartz was cut and followed southward

by a drift. The vein is about 4 feet wide but is barren. A crosscut to the east cut a small quartz vein with some very rich pockets. This vein, which also is cut off by a fault, resembles the eastern vein in tunnel 2 in character, but correlations between the veins exposed in the different workings have not been established.

The ore is transported by an aerial tramway to a 15-ton Denver mill operated by water power. The tailings are ponded for future treatment. The Mabel mine and mill were operated in 1918 on a small scale.

### TALKEETNA GOLD MINING CO.

The mine and mill of the Talkeetna Gold Mining Co., previously known as the Matanuska Gold Mining Co., were operated during a part of the season of 1918. This property is on the north side of Fairangel Creek, near its head.

### ANCHORAGE GOLD MINES CO.

The Pearl, Glacier, and Teddy groups of claims on Archangel Creek near the glacier were taken over by the Anchorage Gold Mines Co., recently organized in Anchorage. The company is represented by Byron Bartholf, president; Sidney Anderson, vice president; A. G. Thompson, secretary; and E. M. Culbertson, treasurer. It is the plan of the company to start active development as soon as weather conditions permit.

### LE ROI MINING CO.'S PROPERTY.

The property of the Le Roi Mining Co. is on Good Hope Creek, a tributary of Reed Creek, near the summit of the high divide east of the main creek and about 1¼ miles northeast of the mouth of the creek and 1½ miles east of the Mabel mine. This deposit was discovered in 1917, and since then temporary work has been in progress. A wagon road from the Willow Creek road was built, mining equipment assembled, and underground work started.

### WEBFOOT AND RUTLAND PROSPECTS.

Some development work was done by Gaikema & Conroy on the Webfoot and Rutland groups of claims, near the junction of Archangel and Fairangel creeks. The vein on the Webfoot is reported to be exposed by surface stripping for a claim length. Some development work was also done on the Gem prospect in the same locality. On the Fern and Goodell claims a tunnel was driven 300 feet along the lode, and work was continued during the winter.

# PLACER MINING IN THE TOLOVANA DISTRICT.

By R. M. Overbeck.

## INTRODUCTION.

Mining in the Tolovana district in 1918 was practically restricted to the gold placer deposits in the vicinity of Livengood. A little placer mining was done in the western part of the district on Gunnison and Quail creeks, but prospecting, both for placers and for lodes, except at Livengood, was negligible. Development work was done on a lode near Livengood, which is reported to carry gold and nickel. Other minerals occurring in the district not yet known in sufficient quantity to be of economic value are chromite (chrome ore), scheelite (tungsten ore), stibnite (antimony ore), and possibly platinum.

The value of the output of placer gold in the Tolovana district in 1918 was about $875,000, compared with $1,160,000 in 1917. This is about 15 per cent of the total placer gold production of Alaska in 1918 and gives the Tolovana district second place among the placer districts. The total production of the district to the end of 1918 was about $2,805,000. The decrease in 1918 was due largely to the working out of claims, but also to lack of water resulting from the exceptionally dry summer, to the scarcity of labor, and to the high cost of supplies. About 35 mines were operated in 1918, compared with 50 in 1917, and about 270 men were engaged in mining. Three or four of the plants employed more than 25 men. About eight of the mines were worked out during the season, or the deposits were found to be of too low grade to be worked in 1919. At three mines the winter's dumps of 1917 were sluiced and operations then ceased. The decrease in mining led to many persons leaving Livengood in the fall of 1918.

Mertie[1] has already given a rather detailed account of the mines and mining conditions in the Tolovana district. In order to avoid unnecessary repetition, the facts given here will be as far as possible supplementary to his account.

Livengood, locally called Brooks, the center of mining on Livengood Creek and its tributaries, is about 56 miles by trail from Olnes, a station on the Tanana Railroad. Supplies and mail are brought

[1] Mertie, J. B., jr., The gold placers of the Tolovana district: U. S. Geol. Survey Bull. 662, pp. 221-277, 1917.

to Livengood over the trail in winter and by boat up the Tolovana River in summer. An automobile tram connects Livengood with the head of navigation on Tolovana River. The town is in communication with Fairbanks by wireless telegraph and with the mines on the creeks by telephone. Timber for fuel and mining is locally available, but the ground, fortunately, is well frozen, and little timbering is needed in the mines. The camp is handicapped by scarcity of water for sluicing, most of which is taken from Livengood Creek and its tributaries. Owing to abnormal economic conditions in 1918, figures on cost of labor and of supplies are of little value.

The gold placers of the Tolovana district are of three types—(1) placers in the present streams; (2) bench placers in the buried channels of former streams, which are the richest; and (3) disseminated placers in the fans at the mouths of some of the gulches. The placers of the first two types show either irregular concentration of the gold or well-defined pay streaks on or near bedrock; those of the other type show a general dissemination of the gold throughout the unconsolidated material of the fan. Some of the disseminated deposits might become of importance if plenty of water could be had for sluicing.

Most of the gold in the district has come from the buried or bench placers along the north side of the valley of Livengood Creek. The placers in the creek itself have never been important producers, and in 1918 none of them were being worked. The most productive tributary of Livengood Creek is Amy Creek, which enters Livengood Creek from the south about 3 miles above the town. Ruth, Gertrude, and Goodluck creeks, which also enter from the south, have produced some gold. The streams from the north are unproductive. Lillian Creek, which flows into Livengood Creek below its junction with Myrtle Creek, and Olive Creek, a tributary of Tolovana River, are being worked at present.

## MINING OPERATIONS.

### LIVENGOOD CREEK.

Livengood Valley is markedly asymmetric, having a steep south side and a gently sloping north side. Livengood Creek flows along the steep wall of the south side. Benches are prominent physiographic features on both sides of the valley. The buried channel now being mined is on the north side, about half a mile from Livengood Creek. It is only at shallow depth near the head of the valley but deepens downstream, being about 200 feet below the present valley bottom at the junction of Amy and Livengood creeks.

The physiographic history of Livengood Creek has been outlined by Mertie. The shifting of the divide between Livengood Creek and

South Fork of Hess Creek has been well established, and little doubt can exist that Amy, Lucky, Wonder, and Heine creeks were at one time tributary to Hess Creek. Many details of the history can not be deciphered, however, without a detailed topographic map and accurate determination of elevation. The depths to bedrock, as shown by shafts and prospect holes, for example, are of little value for comparison unless the elevation of the top of the shaft is known. The positions of the working shafts were determined in 1918 by foot traverse, and their elevation by barometer readings. Unfortunately, only a few plants were being operated when the camp was visited, and reliable information about those that had shut down could not be obtained. Mertie[1] has noted the steepened grade of the buried channel near the lower end of the valley. More recent data indicate that the rather abrupt steepening in the channel shown by the greatly increased distance to bedrock is farther up the valley than had been supposed. The reason for the preservation of this steep grade is not definitely known, but Mertie believes that it represents the head of a stream which was preserved by being silted up and that the more gentle grade of the stream above the break was due to a halt in the change of base-level. Most streams show changes in their gradient that are due to the difference in resistance of the rock over which they run; so it does not seem necessary to interpret the change here as a result of the change in regional base-level. Oscillations in base-level, regional or local, have plainly occurred, for the buried channel is cut by watercourses, which were themselves subsequently buried. The width of the pay streak below the break in grade varies between 75 and 180 feet; above the break between 100 and 365 feet. No particular difference in coarseness of gravel could be noted from shafts on the steepened part of the channel.

The gold placers of the buried channel are not of the same type throughout the valley. Near the lower end of the valley the pay streak is rather well defined, but in the upper end it is extremely irregular. In the lower part of the valley, for instance, on different claims the widths of pay streak worked are 135, 180, 120, 75, 150, 365, 100, and 260 feet. The gold is fairly well distributed through the channel, but naturally a certain amount of irregularity occurs. It lies on or very close to bedrock. The thickness of gravels being mined is about 5 feet. At some of the mines as much as 2½ feet of bedrock carried gold; at other mines only a few inches. Shafts in the lower part of the valley are 90 to 140 feet deep. The gold from these claims is mostly fine, but it shows considerable variation in appearance, even from different parts of the same claim. The gravel

[1] Mertie, J. B., jr., op. cit., pp. 260–262.

on the dumps is moderately coarse, but not nearly so coarse as gravels from the head of the valley. Bedrock in some of the mines is level; in others it shows some irregularity. The bedrock is of different types, and most of the different kinds of rocks in the district are represented. One claim lies out of the general alinement of the channel. Here the gold is coarse, and the gravel consists in part of boulders a foot or more in diameter. This offset deposit is thought to represent a side stream entering the old channel from the south.

The occurrence of the gold in the claims in the upper part of the valley is characterized by extreme irregularity. Work on some of the claims was started only recently, although they had previously been prospected without results. The working shafts are about 50 feet deep. On some of the claims the tenor per foot is about the average of the district. The bedrock has an extremely irregular surface, and it appears that the gold occurs on the high points of this floor. The placer deposit is from 1½ to 4 feet thick, and the gravel is coarse. On one of the claims rounded boulders 3 feet in diameter were found. The presence of the coarse gravel indicates a steep gradient for the stream, and consequent irregularities in the deposition of the gold are to be expected. The irregular nature of the bedrock and the presence of the gold on the high points of the bedrock may possibly indicate remnants of an original channel now partly eroded.

The chief method of mining in the district described by Mertie[1] is as follows:

The placer mining on the Livengood bench is accomplished entirely by underground methods. A shaft is sunk to bedrock and tunnels are driven in two directions from the bottom of the shaft, along the line of the pay streak, as far as it is expected that the ground will be worked from that particular shaft. From the ends of the two tunnels crosscuts are made to the lateral limits of the auriferous gravel, and, the piece of ground to be worked having thus been blocked out, the gravel is removed by a retreating long-wall system, working toward the shaft. It is feasible to work 150 or 200 feet in either direction, and hence blocks of ground 30,000 to 40,000 square feet in extent are commonly cleaned from a single shaft.

The underground conditions for mining are excellent. The ground is solidly frozen from top to bottom. No water is present in the workings, because so far no thawed ground or underground watercourses have been encountered. The ground is therefore solid, and little or no timbering is necessary. Examination of untimbered workings a year old, from which all the gravel has been removed, show no tendency of the roof to cave. These favorable conditions have rendered mining much more economical than in the Fairbanks district.

In thawing ground in the tunnels 8-foot steam points are commonly used. These are placed 2 feet apart, thus rendering the duty of each point 4 square feet on a face, or about 1.2 cubic yards. It is estimated that 1 horsepower is required to each steam point.

[1] Mertie, J. B., jr., op. cit., pp. 266–267.

After thawing, the gravel and bedrock is picked loose and conveyed by wheelbarrow to the shaft, whence it is elevated to the surface, conveyed by an overhead cable to the desired spot, and dumped from self-dumping carriers. Sluicing is carried on in the usual manner. Tailing room is usually procured by groundsluicing off a channel in the muck, in the direction of Livengood Creek, but occasionally it is necessary to elevate the sluice boxes in order to obtain sufficient grade.

### AMY CREEK.

Four or five claims in the Amy Creek valley were mined in 1918, and one plant was running at the time of visit. The plants are all within a mile of the mouth of the present creek and are on a bench along the east side of the valley, 150 feet or less above the present creek bed. Shafts on different claims range in depth from 25 to 100 feet. The gold is in fairly coarse gravels on or near bedrock. The pay streak ranges from 40 to 160 feet in width, and the thickness of pay gravels is about 3 feet. The gold is variable but tends to be rather fine. Bedrock where cleaned is fairly level and does not show the marked irregularities of upper Livengood Creek. On three of the claims the bedrock is limestone. The shafts are put down through slide and clear ice, so that in some of the mines the tendency of the gravel to slab is much greater than on Livengood Creek. Movement of the surface of the ground, due probably to thawing of the ice, is at places so great that buildings are moved out of position. Underground work has been insufficient to allow a definite pay streak to be recognized and traced. From the alinement of plants, however, it would seem that the pay streak swings into Livengood Creek, an indication that the deposition of gold in the present channel took place when Amy Creek was a tributary of Livengood Creek.

### GERTRUDE CREEK.

No mining was done on Gertrude Creek in 1918. A bench at the mouth of the creek was hydraulicked, and about 12,000 feet of bedrock was cleaned. The value of the gold per foot was much lower than the average value for the district.

### RUTH CREEK.

A little groundsluicing was done on Ruth Creek in 1918, but the work was handicapped by scarcity of water. The gold here occurs in the gravels of the present stream.

### LILLIAN CREEK.

About five claims were worked on Lillian Creek. The claims near the head of the creek are worked by open cuts, and one near the mouth of the creek by the underground method. Lillian Creek is a very short stream having a steep slope, and its valley is filled with

slide and coarse gravel. The creek itself carries little gold, but the low benches on either side of it are productive. The gold is rather fine and is scattered through the gravel, which is from 5 to 10 feet thick. The bedrock has a very irregular surface and pitches steeply down the creek.

The plant for underground work is in the washed and slide material at the place where the creek debouches into Livengood Valley. The gold here is distributed throughout the unconsolidated material and is not concentrated near bedrock. The gravel is bouldery and unsorted. The gold is so very fine that a large percentage of it is lost in the clean-up. A ditch that was installed during the summer brings water from Livengood Creek, and it is intended to work these gravels in 1919 by open-cut methods.

### OLIVE CREEK.

Work was done on three claims on Olive Creek, all by open cuts. Conditions on Olive Creek are similar to those on Lillian Creek. The gold is very fine and is distributed throughout the gravel. The uppermost claim on the creek has a cut 90 feet wide, but the width of the pay streak is not known. The gravel is from 10 to 15 feet thick, and muck covering the gravel is at most 2 feet thick. The width of the pay streak on the lower claims has not yet been determined, and gold is not confined to bedrock. The depth to bedrock on the claim nearest the mouth of the creek is reported to be about 90 feet. The gold is distributed through the gravel.

### QUAIL CREEK.

Quail Creek, a tributary to Troublesome Creek, was not visited, but it is reported that one man was working on it for part of the summer.

### GUNNISON CREEK.

Four men worked part of the summer on Gunnison Creek, in the western part of the district. Gold was found in the creek gravels, and a dam for groundsluicing was constructed. Work was stopped in the middle of the summer.

## SOURCE OF PLACER GOLD.

Although the bedrock source of the placer gold in the Tolovana district has not been definitely determined, there is much information on the general distribution of mineralization. Most of the gold placers of central Alaska are more or less closely associated with granitic and dioritic intrusive rocks, and this is also true of the Tolovana district. Rocks of this type occur south of Livengood Creek,

and there some gold-bearing quartz stringers have been discovered. These rocks are absent north of Livengood Creek, and here no evidence of mineralization has been found. It is clear, therefore, that the placer gold is genetically related to the igneous rocks.

Gold lode claims have been located on the ridge at the head of Ruth and Olive creeks, and on one of them some development work has been done which has been described fully by Mertie.[1] Mineralized rock of similar type was seen in Alder Gulch and on Gertrude Creek and is reported to extend to Amy Dome, but this has not been proved. A specimen of the rock from the ridge consists of dolomite, quartz, calcite, and minute specks of sulphide and contains nickel. A similar specimen from Gertrude Creek contains only a trace of nickel. The sulphides were too minute to be determined.

Some evidence of the distribution of mineralization was obtained by a study of concentrates from different parts of Livengood Creek. Concentrates from the creeks that drain Money Knob have a similar mineral composition. Those from Ruth Creek, for example, contain much scheelite, some magnetite, and a little cinnabar, chromite, pyrite, arsenopyrite, and zircon. Those from Lillian and Olive creeks are similar, except that stibnite also is found on Lillian Creek. Cinnabar is particularly abundant on Olive Creek and is derived from a weathered granite near the head of the creek. The stibnite occurs as stringers in a deeply weathered iron-stained rock of indeterminate character. Chromite, probably derived from serpentine, is also abundant. Magnetite, pyrite, arsenopyrite, and zircon are widespread and have little correlative value in determining the derivation of the gold. Scheelite, cinnabar, and stibnite probably have a common origin with the gold.

The concentrates from the bench claims of the north side of Livengood Valley, on the other hand, do not show this same association of minerals, and the gold of the bench deposits (old channel) had a somewhat different mode of origin from that of the creeks described above. Stibnite is found on one bench claim near the head of Livengood Valley in place in the weathered bedrock. A little cinnabar was found in the concentrates from a claim nearer the head of the valley. The gold of the upper part of the valley is angular and does not seem to have been carried far. Chromite is rather abundant in the concentrates from these upper claims. Concentrates from deposits opposite the mouth of Amy Creek are characterized by an abundance of pyrite and by some barite. Concentrates from the lower end of Livengood Creek contain magnetite, hematite, barite, chromite, arsenopyrite, zircon, pyrite, calcite, and quartz. None of these minerals are characteristic, although the absence of scheelite,

[1] Mertie, J. B., jr., op. cit., pp. 273–274.

cinnabar, and stibnite must be noted. If the gold of these lower valley bench claims were derived from Money Knob, some of the representatives of these minerals should have been found with the concentrates. Amy Creek shows magnetite, limonite, hematite, chromite, quartz, and on one claim pyromorphite (lead phosphate). The pyromorphite is derived probably from the limestone that forms the bedrock. Magnetite, which occurs in most of the concentrates, probably comes in large part from the serpentine, and the hematite and limonite may in turn represent altered magnetite.

## PLATINUM.

No platinum was found in any of the concentrates by the writer, but a very small nugget was given to him which was reported to have come from a clean-up, and there is no reason to doubt this statement. Platinum is known to occur chiefly in placers derived from bodies of basic igneous rocks, such as serpentine. In view of the presence of much serpentine and of the occurrence of much chromite in the district, placer miners will be justified in searching for platinum among the concentrates.

# MINING IN NORTHWESTERN ALASKA.

By S. H. Cathcart.

## INTRODUCTION.

The season of 1918 was the most unfavorable for placer mining that the Seward Peninsula has experienced. Several factors combine to account for the great falling off in production, namely, frost, water shortage, labor difficulties, high cost of operating, and the short season. The lateness of snowfall the preceding winter, when the ground was not covered until February, resulted in deep frost that prevented many dredges from digging until late in the season and others from operating at all. In the Solomon River district frost as deep as 10 feet was reported, and in the Council City district frost was encountered at a depth of 18 inches as late as September.

The scant winter snow and light summer rainfall resulted in a water shortage which affected all open-cut and some dredging operations. Hydraulicking was carried on intermittently and was stopped October 3 by the early freeze-up.

The demand of the Nome labor union for an eight-hour day without overtime and a minimum wage of $5 resulted in contention between the union and the operators which was not satisfactorily adjusted. The operators objected to the demand for no overtime, and consequently most mines were short-handed or employed inefficient help.

Increased cost of transportation, repair parts for machinery, labor, fuel, and foodstuffs was felt severely in all mining operations. It is estimated that the cost of production in 1918 was 30 to 40 per cent greater than under normal conditions.

The season was unusually short. Ice did not leave Bering Sea until July and delayed the arrival of the first boat until June 25. Ditch and creek waters froze October 3, and the first 6 inches of snow fell a few days later.

As a result of the adverse conditions outlined above the value of the mineral production of Seward Peninsula in 1918 was only about $1,195,172, compared with $2,747,000 in 1917. Of the output in 1918,

$1,108,000 represents the value of the placer gold and $87,172 the value of the miscellaneous products, including tin, tungsten, silver, and platinum.

## GOLD.

### TOTAL PRODUCTION.

The production of placer gold was less than half that of 1917 and was the smallest since 1898. The decrease was due to the unavoidable conditions already cited.

The details of the production of placer gold in Seward Peninsula in 1918 are given in the following tables in so far as it is possible to do so without disclosing individual production:

*Placer gold produced in Seward Peninsula, 1918, by districts.*

| District. | Operations. | Mines. | Men employed. | Production. | Per cent of production. |
|---|---|---|---|---|---|
| Nome | Dredges | 6 | 42 | $107,000 | |
| | Hydraulic | 10 | 93 | 160,000 | |
| | Underground | 21 | 125 | 133,000 | |
| | Open-cut | 13 | 20 | 47,000 | |
| | | 50 | 280 | 447,000 | 40.3 |
| Solomon | Dredges | 5 | 34 | | |
| | Hydraulic | 1 | 5 | | |
| | | 6 | 39 | 49,000 | 4.4 |
| Council | Dredges | 7 | 50 | 258,000 | |
| | Hydraulic | 4 | 20 | 41,000 | |
| | Open-cut | 6 | 9 | 8,000 | |
| | | 17 | 79 | 307,000 | 27.7 |
| Fairhaven | Dredges | 2 | 18 | 17,000 | |
| | Hydraulic | 5 | 40 | 39,500 | |
| | Underground | 4 | 16 | 31,000 | |
| | Open-cut | 11 | 24 | 25,500 | |
| | | 22 | 98 | 113,000 | 10.2 |
| Koyuk [a] | Hydraulic | 3 | 8 | 10,000 | |
| | Underground | 3 | 36 | 115,000 | |
| | Open-cut | 4 | 14 | 10,000 | |
| | | 10 | 58 | 135,000 | 12.2 |
| Kougarok | Dredge | 1 | 8 | | |
| | Hydraulic | 1 | 4 | | |
| | Open-cut | 15 | 47 | | |
| | | 17 | 59 | 50,000 | 4.5 |
| Port Clarence | do | 6 | 20 | 7,000 | .6 |
| Grand total | | 128 | 633 | 1,108,000 | |

[a] Hydraulic and open-cut production in the Koyuk district only approximately proportioned.

Placer gold is recovered on Seward Peninsula by underground mining, dredging, and open-cut work, including hydraulicking. The relative importance of the several methods so far as known is shown as follows:

*Placer gold produced in Seward Peninsula, 1918, by methods of mining.*

| Method. | Number of mines. | Number of men employed. | Production. | Per cent of production. |
|---|---|---|---|---|
| Dredging | 21 | 152 | $466,000 | 42.1 |
| Underground | 28 | 177 | 279,000 | 25.2 |
| Hydraulic | 24 | 170 | 259,500 | 23.4 |
| Open-cut other than hydraulic | 55 | 134 | 103,500 | 9.3 |
| | 128 | 633 | 1,108,000 | .......... |

## DREDGES.

Twenty-one gold dredges operated during the season of 1918, as compared with 28 in 1917, 27 in 1916, and 31 in 1915. Six of these were in the Nome district, seven in the Council district, five in the Solomon district, two in the Fairhaven district, and one in the Kougarok district.

*Dredges operating on Seward Peninsula, 1918.*

NOME DISTRICT.

| | |
|---|---|
| Dexter Dredging Co | Dexter Creek. |
| Glacier Creek dredge | Glacier Creek. |
| Bangor Creek Dredging Co | Bangor Creek. |
| Center Creek Dredging Co | Center Creek. |
| Hastings Creek dredge | Hastings Creek. |
| Julien Dredging Co | Osborn Creek. |

SOLOMON DISTRICT.

| | |
|---|---|
| Esquimo Dredging Co | Solomon River. |
| Flowers dredge | Do. |
| Scott-Newburg dredge | Do. |
| Shovel Creek Gold Dredging Co | Shovel Creek. |
| Burners-Iverson-Johnson dredge | Big Hurrah Creek. |

COUNCIL DISTRICT.

| | |
|---|---|
| Blue Goose Mining Co | Ophir Creek. |
| Northern Light Mining Co | Do. |
| Wild Goose Mining & Trading Co | Do. |
| Uplift Mining Co | Camp Creek. |
| G. & O. Dredging Co | Elkhorn Creek. |
| Moody Mining Co | Canyon Creek. |
| Goose Creek dredge | Goose Creek. |

KOUGAROK DISTRICT.

| | |
|---|---|
| Behring Dredging Co | Taylor Creek. |

FAIRHAVEN DISTRICT.

| | |
|---|---|
| Candle Creek Dredging Co | Candle Creek. |
| Fries Dredging Co | Inmachuk River. |

It is estimated that the 21 gold dredges operating on Seward Peninsula in 1918 employed 152 men and produced gold to the value of $466,000, or 42.1 per cent of the total production of the peninsula. It is difficult to estimate the quantity of gravel handled, and, consequently, the average value of the gravel worked in 1918, as, except at very few places, the frozen condition of the ground interfered with operations and made much unproductive digging necessary; but the information at hand indicates that about 1,164,000 cubic yards of gravel was handled and that the recovery per cubic yard was about 40 cents.

### UNDERGROUND MINING.

Twenty-eight deep placer mines, employing about 177 men, were worked on Seward Peninsula in 1918. The production is estimated at $279,000, or 25.2 per cent of the total production of the peninsula. The distribution of the mines so far as known is as follows:

*Deep placers worked on Seward Peninsula in 1918.*

| | | | |
|---|---|---|---|
| NOME DISTRICT. | | KOYUK DISTRICT. | |
| Submarine | 5 | Dime Creek | 3 |
| Second beach | 2 | FAIRHAVEN DISTRICT. | |
| Third beach | 5 | Inmachuk River | 1 |
| Center Creek | 1 | Candle Creek | 3 |
| Dexter Hill | 8 | | |
| | 21 | | 4 |

### OPEN-CUT MINING.

Twenty-four hydraulic operations, employing about 170 men, and 55 open-cut mines other than hydraulic, employing about 134 men, were worked on Seward Peninsula in 1918. It is estimated that the hydraulic operations produced $259,500, or 23.4 per cent, and other open-cut works $103,500, or 9.3 per cent, of the total production of the peninsula. The distribution of these mines is, so far as known, as follows:

*Hydraulic operations on Seward Peninsula in 1918.*

| | | | |
|---|---|---|---|
| NOME DISTRICT. | | NOME DISTRICT—continued. | |
| Little Creek | 1 | Dry Creek | 1 |
| Monument Creek | 1 | Dexter Creek | 1 |
| Boulder Creek | 1 | Bangor Creek | 1 |
| Osborn Creek | 1 | | |
| Rock Creek | 1 | | 10 |
| Gold Bottom Creek | 1 | | |

KOYUK DISTRICT.

| | |
|---|---|
| Dime Creek | 2 |
| Sweepstake Creek | 1 |
| | 3 |

SOLOMON DISTRICT.

| | |
|---|---|
| Big Hurrah Creek | 1 |

FAIRHAVEN DISTRICT.

| | |
|---|---|
| Bear Creek | 1 |
| Patterson Creek | 2 |
| Jump Creek | 1 |

FAIRHAVEN DISTRICT—continued.

| | |
|---|---|
| Johnny Bull Hill | 1 |
| | 5 |

COUNCIL DISTRICT.

| | |
|---|---|
| Ophir Creek | 1 |
| Casadepaga River | 3 |
| | 4 |

KOUGAROK DISTRICT.

| | |
|---|---|
| Macklin Creek | 1 |

*Open-cut operations other than hydraulic on Seward Peninsula in 1918.*

NOME DISTRICT.

| | |
|---|---|
| Specimen Gulch | 1 |
| Dry Creek | 2 |
| Bear Creek | 1 |
| Nome River | 1 |
| Buster Creek | 2 |
| Oregon Creek | 2 |
| Penny River | 1 |
| Jess Creek | 1 |
| Anvil Creek | 1 |
| Second Beach | 1 |
| | 13 |

KOYUK DISTRICT.

| | |
|---|---|
| Dime Creek | 4 |

PORT CLARENCE DISTRICT.

| | |
|---|---|
| Gold Run | 1 |
| Bluestone | 4 |
| Coyote Creek | 1 |
| | 6 |

FAIRHAVEN DISTRICT.

| | |
|---|---|
| Candle Creek | 8 |
| Inmachuk River | 3 |
| | 11 |

COUNCIL DISTRICT.

| | |
|---|---|
| Dutch Gulch | 1 |
| Warm Creek | 2 |
| Albion Creek | 1 |
| Sunshine Creek | 1 |
| Tubutulik River | 1 |
| | 6 |

KOUGAROK DISTRICT.

| | |
|---|---|
| Dahl Creek | 3 |
| Quartz Creek | 1 |
| Wonder Gulch | 1 |
| Harris Creek | 2 |
| Arizona Creek | 1 |
| Homestake Creek | 1 |
| Humboldt Creek | 1 |
| Dick Creek | 1 |
| Coffee Creek | 1 |
| Garfield Creek | 1 |
| Boulder Creek | 1 |
| Kougarok River | 1 |
| | 15 |

Hydraulic elevators were used on Little, Osborn, and Ophir creeks, Rubel elevators on Candle and Bear creeks, and a steam scraper on Dime Creek.

## DISCOVERIES.

The only new strike of the season was made by Connelly & Listen on Poorman bench, off No. 6, Monument Creek, in the Nome district. Gravels carrying about $32 to the cubic yard were opened. The adjoining claims were being prospected late in the summer but with little success. Considerable winter work is planned which will no doubt show the extent of the deposit. The locality was visited by the writer, but not until after the ground was covered by 7 inches of snow. The claim was opened by a pit 40 by 60 by 6 feet. The ground was hydraulicked, and work suffered from water shortage. Where the rich gravels were found the bedrock surface reverses its slope from east to west and slopes into the hill at an angle of about

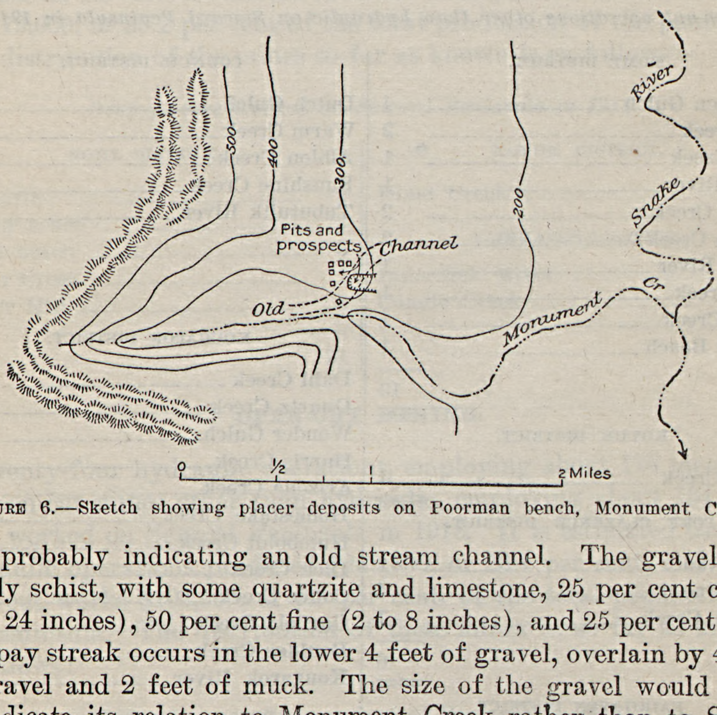



FIGURE 6.—Sketch showing placer deposits on Poorman bench, Monument Creek.

20°, probably indicating an old stream channel. The gravels are mostly schist, with some quartzite and limestone, 25 per cent coarse (8 to 24 inches), 50 per cent fine (2 to 8 inches), and 25 per cent clay. The pay streak occurs in the lower 4 feet of gravel, overlain by 4 feet of gravel and 2 feet of muck. The size of the gravel would seem to indicate its relation to Monument Creek rather than to Snake River deposits. This conclusion is further borne out by the absence, in these concentrates, of scheelite, which occurs in the Snake River gravels but not in the gravels of Monument Creek. A sketch of the occurrence so far as known is shown in figure 6.

## THAWING.

The use of cold water—that is, water at the normal summer temperature of ponds, ditches, and creeks—in thawing perpetually frozen muck and gravel is a recent development that promises to be

of value to the placer miners of Alaska. The idea is perhaps not entirely new, but its application to mining was not successfully demonstrated until the season of 1918. The method is far from being established, and much experimental work remains to be done before its real value and limitations are known. It promises to be an economical means of thawing ground for dredging and open-cut mining. The available data on the subject are given below.

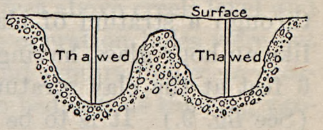



FIGURE 7.—Sketch showing results of thawing by hot water and steam at boiler temperature.

Experiments were made during the season of 1917 under the direction of John Miles for the Alaska Mines Corporation, on its ground near Nome, for the purpose of determining the most efficient and economical means of thawing the deep Nome gravels for dredging. Superheated steam at a temperature of 1,000° F., steam at boiler temperature, hot water at 150° to 180° F., and water at stream temperature of 52° F. were used in the experiments.

In the experiments in which steam and hot water were used three holes were drilled to bedrock at the points of an equilateral triangle 12 feet apart, and at a point intermediate between them a test hole was drilled, which was cased and kept open to determine when the ground had thawed to the center. Shafts were sunk in the thawed ground, and drifts were run to the limits of the thawed area. In the tests in which hot water and steam at boiler temperature were used the thawed area tended to cone downward, leaving horsts of unthawed ground on bedrock. (See fig. 7.) Superheated steam at 1,000° F. gave results as shown in figure 8. The thawed area was greatest on bedrock, and where a clay stratum was encountered the hole did not pinch.

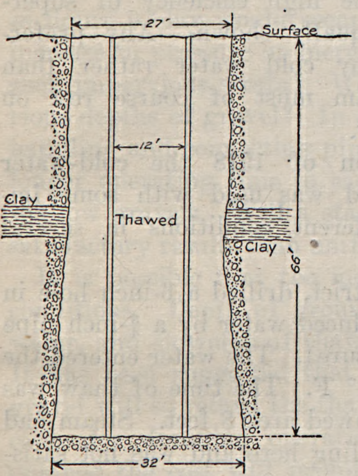



FIGURE 8.—Sketch showing results of thawing by superheated steam.

Two holes were thawed by the cold-water method, both single holes without the test holes used in the foregoing experiments. One hole was 43½ feet and the other 50 feet deep. Both were 6-inch holes drilled to bedrock with an Empire drill. A 2-inch pipe was inserted to bedrock, and a small gas engine developing not more than 30 pounds pressure was used to force water down the pipe. The water was allowed to run from the bottom of the pipe and flow over the surface, the circulating water thawing the ice out of the

muck and gravel. As no test holes were used, it was not possible to tell how rapidly the thawing progressed until the ground began to slough in at the surface. This required from five to six days. The shrinkage in the thawed ground was about one-third, which represents the volume of ice present in the muck and gravel. The temperature of the water issuing from the hole was not taken. A shaft sunk in the thawed ground showed the holes to have passed through a stratum of clay. The area thawed was in cross section like an hour glass, having a width of 22 feet on bedrock, pinching to 6 feet at the clay stratum and widening to 18 feet at the surface. (See fig. 9.) It is to be noted that the thawing was most effective where it was most desired—on bedrock.

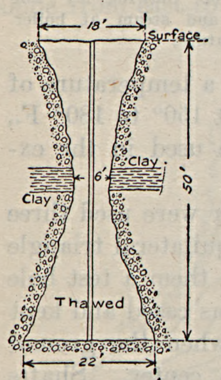


FIGURE 9.—Sketch showing results of thawing by water at stream temperature.

Sufficient work was not done nor were sufficient quantitative data collected to warrant any extensive conclusions, but the experiments are interesting in that they demonstrate the ability of cold water to thaw frozen ground and to thaw effectively on bedrock. Otherwise stated, they demonstrate the efficiency of a heat unit which is near the freezing point and available by natural processes. The moderate efficiency of hot water and boiler steam and the high efficiency of superheated steam are equally shown. Any preference for thawing by cold water rather than by superheated steam must of course rest on grounds of economy.

During the season of 1918 the cold-water method just outlined was used with some important modifications and under different conditions in several operations.

Pierce & Johnson, in the Candle district, drilled a 6-inch hole in 24 feet of muck (no gravel) and introduced water by a ¾-inch pipe under a head of 15 feet (6 pounds pressure). The water entered the ground at 42° F. and left at 32° to 34° F. The time of thaw was seven days, and the diameter of the thawed area 8 feet. Steam had been tried under the conditions prevailing here and was not satisfactory. Water did the work well.

The same company used cold water in thawing creek gravels preparatory to dredging. The ground thawed was 12 or 13 feet deep and consisted of 4 to 5 feet of clay and muck, 4 to 5 feet of gravel, and 3 feet of soft blue-clay bedrock. A battery of forty ¾-inch points was used, the points spaced in squares 5 feet apart. It was found by trial that 5-foot spacing required 48 hours to thaw, and that the thaw was perfect, whereas 10-foot spacing required 96 hours to thaw, and horsts of unthawed material were left on bedrock. The water

entered the ground at 42° F. and came from the thaw at 38° to 39° F. Water under a head of 24 feet (10.4 pounds pressure) was used. The thawing took place first and was widest on bedrock. Shrinkage of as much as 3 feet was observed and was confined almost entirely to the muck. It is estimated that 60 miner's inches of water was used to run the 40 points continuously. Three men were employed, two on the day and one on the night shift. A 50-horsepower engine was used to pump water to a reservoir 24 feet above creek level and was run three hours in each eight. In this operation holes were not drilled. The points were set with water and required only an occasional twist with a Stilson to force them to bedrock as thawing progressed.

Some of the questions still to be answered that will probably influence the successful working of the process are, What quantity of water and what water pressure will give best results—that is, thorough thaw in the least time, in deep or shallow gravels, in the presence of sand, clay, muck, etc.? Is a heat unit just above freezing as efficient as one 5° above freezing? If so, the least possible pressure to insure circulation should be used; if not, the pressure should be increased to insure removal of the water before it is lowered to an inefficient temperature. What is the relation of rate of thawing to character of ground and depth of gravel? From the case illustrated in figure 9 clay would seem to require special consideration. Will increase in pressure or increase in time be more efficient in thawing such impervious strata? What is the most efficient spacing for various depths of gravel? In deep gravels the dead work necessary in handling and connecting pipe will probably justify fewer holes and longer operating time to each thaw than will be found efficient in shallow gravels. Will a staggered arrangement of holes give more satisfactory results than uniform spacing?

It is possible that the method may not be applicable under all conditions. Depth of ground, character of ground, availability of water, and slowness of thaw may be factors that will limit its use. It has been suggested that in the Nome region the depth of the gravel will so retard the thawing that this method will be impracticable for dredging operations. Also that where water must be pumped the cost will prohibit the use of the method. No quantitative data is available that will prove or disprove these assertions, and opposite views are held by equally competent men. Even though there are limitations to its application, the method will undoubtedly be useful in thawing shallow ground where water is easily available, and that is putting the maximum restriction upon its use. Should it prove applicable to the deep gravels of the Nome coastal plain, it will be the means of opening a large area of dredgeable ground, much of which would not afford the expense of thawing by other methods.

Concerning this point the season of 1919 should furnish additional data, as preparations are now under way to use the process on Dry Creek in conjunction with dredging operations.

Sufficient data are not available to make any general prediction concerning the time required in thawing under various conditions, but the information at hand is summarized below.

In the experimental work on the deep Nome gravels the volume actually thawed amounted to about 50 cubic yards a day for one point using a pressure of about 30 pounds and water at 52° F. The test on muck in the Candle district shows a volume of about 6 cubic yards thawed per point per day, where the water pressure was about 6 pounds, the water temperature 42° F., and the depth of ground 24 feet. The creek gravels thawed at the same locality were 13 feet deep. Water at a pressure of about 10 pounds and a temperature of 42° F. was used, and the rate of thaw is calculated at 6 cubic yards per point per day.

From these figures the rate of thaw in deep gravel would seem to be favorable rather than unfavorable, 20 points being required to supply 1,000 cubic yards of thawed ground a day, as compared with 160 points required to supply a like amount of shallow creek gravel or muck.

The cost of thawing gravels by steam is as follows: The Northern Light Dredge Co. in 1911 thawed 9-foot gravels at a cost of 35 cents a cubic yard, using ten 10-foot points spaced 7 feet apart for 6 to 7 hours. The Esquimo Dredge Co. thawed 12-foot gravels, using 90 points 4 feet apart for 24 hours, at a cost of 7½ cents a cubic yard. If much sand was present in the gravel the cost was 9 cents a cubic yard. Scott & Newburg thawed in the spring of 1918 for 8 days at a cost of 12 cents a cubic yard.

## LODE MINING.

Little work was done on the lodes of Seward Peninsula in 1918. The usual prospecting was almost entirely discontinued, owing in part to the fact that assessment work was not required and in part to the increased cost of such work.

About 20 men under the direction of F. Fearing were engaged in making an examination of the Lost River tin lodes for J. Halpin. The Cassiterite Creek placers were also tested. A force of seven men will be employed in retimbering the workings during the winter. No production was attempted.

Perkypile & Ford propose to do considerable work on a silver-lead lode on Kugruk River, a quarter of a mile east of the mouth of Independence Creek. Six men were employed during the summer under the direction of Edwin Elge. The force was increased to 10

men in the fall, and it is the intention to work 20 men during the winter. A 30-foot shaft has been sunk on the ore body, and a 40-foot tunnel driven. The operators propose to continue the shaft to a depth of 200 feet and to crosscut the ore body. Mr. Ford states that assay returns from an average sample show 150 ounces of silver and $2.45 in gold to the ton, 30 per cent of lead and a trace of zinc. The locality was not visited by the writer, but the deposit is said to occur in marmarized limestone along a limestone-granite contact, to be from 7 to more than 12 feet wide where opened, and to be traceable for 2,000 feet on the surface. (See fig. 10.) About 50 tons of ore is

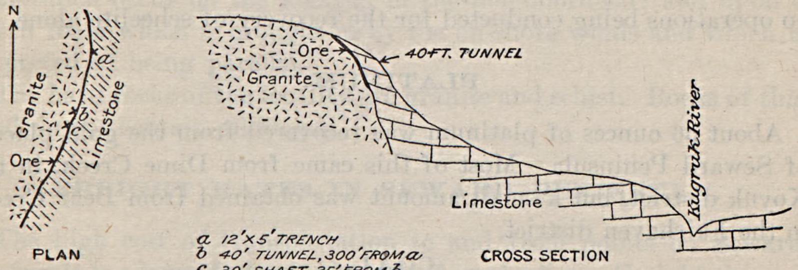



FIGURE 10.—Sketch showing prospect on Kugruk River a quarter of a mile east of the mouth of Independence Creek.

ready for shipment. The ore must be hauled about 50 miles to Willow Bay and lightered to ships.

Hed & Strand report further development on their antimony-gold property on Dahl Gulch, described by Mertie.[1] Another ore shoot has been encountered since Mertie's visit. The ore is reported to carry $15.50 in gold and 2 ounces of silver to the ton. Further work will be done on the lode during the winter of 1918.

## TIN.

The total production of tin in this region was much less than in 1917. Only one tin dredge on Buck Creek, in the York district, operated in 1918. A small amount of tin concentrates was also produced by sluicing. Placer tin has been discovered on Potato Creek, which flows northwest from Potato Mountain, and also on Humboldt Creek, tributary to Goodhope River in the Fairhaven district.

The ground on Potato Creek was prospected in 1918, and it is planned to dredge the creek in the near future. The placers of the Potato Mountain region have supplied practically all the tin produced in the district, but operations have thus far been confined to the streams southeast of the mountain.

[1] Mertie, J. B., jr., Lode mining and prespecting on Seward Peninsula: U. S. Geol. Survey Bull. 662, pp. 437–438, 1918.

Concentrates from Humboldt Creek, a tributary of Good Hope River, in the Fairhaven district, contain cassiterite, the oxide of tin. According to information given by J. Sullivan the placers are of considerable extent but not of high grade. Gold, however, is said to occur with the tin and may make it profitable to mine. Whether of great value of not, the development of placer tin in this region is new.

## TUNGSTEN.

The production of tungsten on Seward Peninsula in 1918 was less than in 1917. It was wholly incident to the mining of placer gold, no operations being conducted for the recovery of scheelite alone.

## PLATINUM.

About 56 ounces of platinum was recovered from the gold placers of Seward Peninsula. Most of this came from Dime Creek, in the Koyuk district, but a small amount was obtained from Bear Creek, in the Fairhaven district.

## COAL.

Coal was mined in a small way in several localities in northwestern Alaska during the summer of 1918.

In the Kobuk region about 150 tons was produced from a mine on Kobuk River about 25 miles above Squirrel River. It is reported to be a bituminous coal of good quality and to have sold in Kotzebue for $17 a ton.

It is estimated that during the summer about 100 tons of coal was shipped to Nome from Unalaklik and probably twice that amount to St. Michael. It sold in Nome for $20 a ton. The deposit is on Coal Mine Creek where it empties into Norton Sound. The bed is reported to cover an area of about 10 miles and to be as much as 6 feet thick. No real development work has been done, and only the weathered outcropping coal has reached the market. The coal is a free-burning lignite, and is valued by local consumers as equivalent to one-half its weight of outside coal. It is easily accessible by coast boat and can readily be marketed along the coast.

It was reported that coal would be mined in the winter of 1918–19 on Kugruk River to supply fuel for the underground placers on the Inmachuk.

## OIL PROSPECTING.

Samuel Kean employed four men in drilling for oil at Cape Nome. An attempt to locate oil at this place was made in 1906, but no work had been done since that time. In 1906 it was reported that at a depth of 122 feet gas was encountered which blew a 1,200-pound

stem 75 feet up the hole. A second hole, 176 feet deep, drilled in 1906, is said to have shown a trace of oil. During the summer of 1918 two wells were drilled. The first well was abandoned at 210 feet owing to the loss of a bailer in the hole; the second had reached a depth of about 150 feet at the end of the season. The company is equipped with a star drill, which is not capable of drilling to any great depth. It is believed that any gas which may have been encountered was derived from the alluvial deposits.

The hopes of the operators are based upon the gas and oil indications encountered in 1906; upon oil-like films of unknown composition which occur on the lagoons in the neighborhood; and upon a beach foam which is brought in by the on-shore winds and which is suspected of being paraffin.

The hard rocks of the locality are granite and schist. Rocks of this kind do not contain oil or gas.

## FREIGHT RATES IN SEWARD PENINSULA.

The high cost of transportation to and from points on Seward Peninsula is a large factor in the cost of production. Freight charges on supplies delivered to camps in the several districts are shown in the attached table. Most operators maintain that any extensive work will be impracticable until steamship rates are reduced.

*Freight cost to certain localities on Seward Peninsula, season of 1918.*

| District. | Locality. | Rate per ton. | |
|---|---|---|---|
| | | By stages. | Total. |
| Budd Creek | Port Clarence | Seattle to Teller $22.50, Teller via lighter to mouth of Agiapuk $12.50, up Agiapuk 50 miles via flatboat $10. | $45.00 |
| Macklin Creek | Kougarok | Seattle to Nome $27, Nome to Teller $17, Teller to Davidson Landing $12.50, overland haul $16. | 72.50 |
| Taylor Creek | do | Seattle to Teller $22.50, Teller to Davidson Landing $12.50, overland haul to Taylor $40. | 75.00 |
| Ophir Creek | Council | San Francisco to Golovin $21, lighterage to Council $35, overland haul $10. | 66.00 |
| Do | do | Seattle to Golovin $20, lighterage to Council $35, overland haul $8. | 63.00 |
| Big Hurrah Creek | Solomon | San Francisco to camp | 52.00 |
| Shovel Creek | do | Seattle to Bonanza $29, overland haul $10 | 39.00 |
| Glacier Creek | Nome | Seattle to Nome $27, overland haul $15 | 42.00 |
| Bangor Creek | do | Seattle to Nome $27, overland haul $25 | 52.00 |

## KOBUK REGION.

The production of placer gold in the Kobuk region in 1918 is estimated at $15,000. About 35 men were engaged in mining operations. The gravels are of low grade and to the small operator offer a grubstake only.

Favorable prospects were found on California Creek, a tributary of the Kogoluktuk, by Fergeson & Melson during the summer. This

is a new strike on both creek and bench pay. The creek gravels seem to be permanently frozen, an unusual condition on the Kobuk, and are about 18 feet thick to bedrock. Extensive preparations were being made for winter work.

In the Squirrel River country about 30 men took out grubstakes only. Several localities in the region are now being prospected by the drill with a view to dredging.

# INDEX.

# RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

All these publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained free of charge (except certain maps) on application.

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost. The publications marked with an asterisk (*) in this list are out of stock at the Survey, but can be purchased from the Superintendent of Documents at the prices stated.

4. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

The maps whose price is stated are sold by the Geological Survey and not by the Superintendent of Documents. On an order amounting to $5 or more at the retail price a discount of 40 per cent is allowed.

### GENERAL.

#### REPORTS.

*The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate, by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper 45, 1906, 327 pp. No copies available. May be consulted at many public libraries.

*Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin 259, 1905, pp. 18–31. 15 cents.

The mining industry in 1905, by A. H. Brooks. In Bulletin 284, 1906, pp. 4–9.

*The mining industry in 1906, by A. H. Brooks. In Bulletin 314, 1907, pp. 19–39. 30 cents.

*The mining industry in 1907, by A. H. Brooks. In Bulletin 345, 1908, pp. 30–53. 45 cents.

*The mining industry in 1908, by A. H. Brooks. In Bulletin 379, 1909, pp. 21–62. 50 cents.

*The mining industry in 1909, by A. H. Brooks. In Bulletin 442, 1910, pp. 20–46. 40 cents.

The mining industry in 1910, by A. H. Brooks. In Bulletin 480, 1911, pp. 21–42.

*The mining industry in 1911, by A. H. Brooks. In Bulletin 520, 1912, pp. 19–44. 50 cents.

The mining industry in 1912, by A. H. Brooks. In Bulletin 542, 1913, pp. 18–51.

*The Alaskan mining industry in 1913, by A. H. Brooks. In Bulletin 592, 1914, pp. 45–74. 60 cents.

The Alaskan mining industry in 1914, by A. H. Brooks. In Bulletin 622, 1915, pp. 15–68.

The Alaskan mining industry in 1915, by A. H. Brooks. In Bulletin 642, 1916, pp. 17–72.

The Alaskan mining industry in 1916, by A. H. Brooks. In Bulletin 662, 1917, pp. 11–62.

The Alaskan mining industry in 1917, by G. C. Martin. In Bulletin 692, 1918, pp. 11–42.

The Alaskan mining industry in 1918, by G. C. Martin. In Bulletin 712, 1919, pp. 11–52.

Railway routes, by A. H. Brooks. In Bulletin 284, 1906, pp. 10–17.

Railway routes from the Pacific seaboard to Fairbanks, Alaska, by A. H. Brooks. In Bulletin 520, 1912, pp. 45–88.

*Geologic features of Alaskan metalliferous lodes, by A. H. Brooks. In Bulletin 480, 1911, pp. 43–93.

*The mineral deposits of Alaska, by A. H. Brooks. In Bulletin 592, 1914, pp. 18–44.

*The future of gold placer mining in Alaska, by A. H. Brooks. In Bulletin 622, 1915, pp. 69–79.

*Tin resources of Alaska, by F. L. Hess. In Bulletin 520, 1912, pp. 89–92. 50 cents.

*The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp. 15 cents.

Alaska coal and its utilization, by A. H. Brooks. Bulletin 442–J, reprinted 1914.

*The possible use of peat fuel in Alaska, by C. A. Davis. In Bulletin 379, 1909, pp. 63–66. 50 cents.

*The preparation and use of peat as a fuel, by C. A. Davis. In Bulletin 442, 1910, pp. 101–132. 40 cents.

*Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin 263, 1905, 362 pp. No copies available. (Abstract in Bulletin 259, 1905, pp. 32–46.)

*Prospecting and mining gold placers in Alaska, by J. P. Hutchins. In Bulletin 345, 1908, pp. 54–77. 45 cents.

*Geographic dictionary of Alaska, by Marcus Baker; second edition prepared by James McCormick. Bulletin 299, 1906, 690 pp. 50 cents.

Tin mining in Alaska, by H. M. Eakin. In Bulletin 622, 1915, pp. 81–94.

Antimony deposits of Alaska, by A. H. Brooks. Bulletin 649, 1916, 67 pp.

The use of the panoramic camera in topographic surveying, by J. W. Bagley. Bulletin 657, 1917, 88 pp.

The mineral springs of Alaska, by G. A. Waring. Water-supply paper 418, 1917, 114 pp.

Alaska's mineral supplies, by A. H. Brooks. Bulletin 666–P, pp. 1–14.

### TOPOGRAPHIC MAPS.

Map of Alaska (A); scale 1:5,000,000; 1912, by A. H. Brooks. 20 cents retail or 12 cents wholesale.

Map of Alaska (B); scale 1:1,500,000; 1915, by A. H. Brooks and R. H. Sargent. 80 cents retail or 48 cents wholesale.

Map of Alaska (C); scale 1:12,000,000; 1916. 1 cent retail or five for 3 cents wholesale.

Map of Alaska showing distribution of mineral deposits; scale 1:5,000,000; by A. H. Brooks. 20 cents retail or 12 cents wholesale. New editions included in Bulletins 642 and 662.

Index map of Alaska, including list of publications; scale 1:5,000,000; by A. H. Brooks. Free.

## SOUTHEASTERN ALASKA.

### REPORTS.

*The Porcupine placer district, Alaska, by C. W. Wright. Bulletin 236, 1904, 35 pp. 15 cents.

*Economic developments in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 259, 1905, pp. 47–68. 15 cents.

*The Juneau gold belt, Alaska, by A. C. Spencer, pp. 1–137, and a reconnaissance of Admiralty Island, Alaska, by C. W. Wright, pp. 138–154. Bulletin 287, 1906, 161 pp. 75 cents.

Lode mining in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 284, 1906, pp. 30–53.

Nonmetallic deposits of southeastern Alaska, by C. W. Wright. In Bulletin 284, 1906, pp. 54–60.

Lode mining in southeastern Alaska, by C. W. Wright. In Bulletin 314, 1907, pp. 47–72.

Nonmetalliferous mineral resources of southeastern Alaska, by C. W. Wright. In Bulletin 314, 1917, pp. 73–81.

Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. In Bulletin 314, 1907, pp. 82–88.

*Lode mining in southeastern Alaska, 1907, by C. W. Wright. In Bulletin 345, 1908, pp. 78–97. 45 cents.

*The building stones and materials of southeastern Alaska, by C. W. Wright. In Bulletin 345, 1908, pp. 116–126. 45 cents.

*The Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright. Bulletin 347, 1908, 210 pp. 60 cents.

*The Yakutat Bay region, Alaska; Physiography and glacial geology, by R. S. Tarr; Areal geology, by R. S. Tarr and B. S. Butler. Professional Paper 64, 1909, 186 pp. 50 cents.

*Mining in southeastern Alaska, by C. W. Wright. In Bulletin 379, 1909, pp. 67–86. 50 cents.

*Mining in southeastern Alaska, by Adolph Knopf. In Bulletin 442, 1910, pp. 133–143. 40 cents.

*Occurrence of iron ore near Haines, by Adolph Knopf. In Bulletin 442, 1910, pp. 144–146. 40 cents.

*Report of water-power reconnaisssance in southeastern Alaska, by J. C. Hoyt. In Bulletin 442, 1910, pp. 147–157. 40 cents.

Geology of the Berners Bay Region, Alaska, by Adolph Knopf. Bulletin 446, 1911, 58 pp.

Mining in southeastern Alaska, by Adolph Knopf. In Bullletin 480, 1911, pp. 94–102.

The Eagle River region, by Adolph Knopf. In Bulletin 480, 1911, pp. 103–111.

The Eagle River region, southeastern Alaska, by Adolph Knopf. Bulletin 502, 1912, 61 pp.

The Sitka mining district, Alaska, by Adolph Knopf. Bulletin 504, 1912, 32 pp.

The earthquakes at Yakutat Bay, Alaska, in September, 1899, by R. S. Tarr and Lawrence Martin, with a preface by G. K. Gilbert. Professional Paper 69, 1912, 135 pp.

Marble resources of Ketchikan and Wrangell districts, by E. F. Burchard. In Bulletin 542, 1913, pp. 52–77.

Marble resources of the Juneau, Skagway, and Sitka districts, by E. F. Burchard. In Bulletin 592, 1914, pp. 95–107.

A barite deposit near Wrangell, by E. F. Burchard. In Bulletin 592, 1914, pp. 109–117.

*Lode mining in the Ketchikan district, by P. S. Smith. In Bulletin 592, 1914, pp. 75–94. 60 cents.

The geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska, by C. W. Wright. Professional Paper 87, 1915, 110 pp.

Mining in the Juneau region, by H. M. Eakin. In Bulletin 622, 1915, pp. 95–102.

Notes on the geology of Gravina Island, Alaska, by P. S. Smith. In Professional Paper 95, 1916, pp. 97–105.

Mining in southeastern Alaska, by Theodore Chapin. In Bulletin 642, 1916, pp. 73–104.

Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 642, 1916, pp. 105–127.

Mining developments in the Ketchikan and Wrangell districts, by Theodore Chapin. In Bulletin 662, 1917, pp. 63–75.

Lode mining in the Juneau gold belt, by H. M. Eakin. In Bulletin 662, 1917, pp. 71–92.

Gold placer mining in the Porcupine district, by H. M. Eakin. In Bulletin 662, 1917, pp. 93–100.

Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 662, 1917, pp. 101–154.

Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 692, 1919, pp. 43–83.

The structure and stratigraphy of Gravina and Revillagigedo islands, Alaska, by Theodore Chapin. In Professional Paper 120–D, 1918, pp. 83–100.

Mining developments in the Ketchikan mining district, by Theodore Chapin. In Bulletin 692, 1919, pp. 85–89.

The geology and mineral resources of the west coast of Chichagof Island, by R. M. Overbeck. In Bulletin 692, 1919, pp. 91–136.

Water-power investigations in southeastern Alaska, by G. H. Canfield. In Bulletin 712, 1920, pp. 53–90.

*In preparation.*

Marble deposits of southeastern Alaska, by E. F. Burchard. Bulletin 682.

The Porcupine district, by H. M. Eakin. Bulletin 699.

The Juneau district, by A. C. Spencer and H. M. Eakin.

Geology of the Glacier Bay and Lituya region, Alaska, by F. E. and C. W. Wright.

The Ketchikan district, Alaska, by Theodore Chapin.

## TOPOGRAPHIC MAPS.

*Juneau gold belt, Alaska; scale, 1:250,000; compiled. In *Bulletin 287. 75 cents. Not issued separately.

Juneau special (No. 581A); scale, 1:62,500; by W. J. Peters. 10 cents retail or 6 cents wholesale.

Berners Bay special (No. 581B); scale, 1:62,500; by R. B. Oliver. 10 cents retail or 6 cents wholesale.

Kasaan Peninsula, Prince of Wales Island (No. 540A); scale, 1:62,500; by D. C. Witherspoon, R. H. Sargent, and J. W. Bagley. 10 cents retail or 6 cents wholesale. Also contained in Professional Paper 87.

Copper Mountain and vicinity, Prince of Wales Island (No. 540B); scale, 1:62,500; by R. H. Sargent. 10 cents retail or 6 cents wholesale. Also contained in Professional Paper 87.

Eagle River region (No. 581C); scale, 1:62,500; by J. W. Bagley, C. E. Giffin, and R. E. Johnson. In Bulletin 502. Not issued separately.

Juneau and vicinity (No. 581D); scale, 1:24,000; contour interval, 50 feet; by D. C. Witherspoon. 10 cents.

### CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

#### REPORTS.

*The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp. 15 cents.

*Geology of the central Copper River region, Alaska, by W. C. Mendenhall, Professional Paper 41, 1905, 133 pp. 50 cents.

*Geology and mineral resources of Controller Bay region, Alaska, by G. C. Martin. Bulletin 335, 1908, 141 pp. 70 cents.

*Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin 345, 1908, pp. 176–178. 45 cents.

Mineral resources of the Kotsina–Chitina region, by F. H. Moffit and A. G. Maddren. Bulletin 374, 1909, 103 pp.

*Copper mining and prospecting on Prince William Sound, by U. S. Grant and D. F. Higgins, jr. In Bulletin 379, 1909, pp. 78–96. 50 cents.

*Gold on Prince William Sound, by U. S. Grant. In Bulletin 379, 1909, p. 97. 50 cents.

Mining in the Kotsina–Chitina, Chistochina, and Valdez Creek regions, by F. H. Moffit. In Bulletin 379, 1909, pp. 153–160.

Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf; with a section on the Quaternary, by S. R. Capps. Bulletin 417, 1910, 64 pp.

Mining in the Chitina district, by F. H. Moffit. In Bulletin 442, 1910, pp. 158–163.

Mining and prospecting on Prince William Sound in 1909, by U. S. Grant. In Bulletin 442, 1910, pp. 164–165.

Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 443, 1910, 89 pp.

Geology and mineral resources of the Nizina district, Alaska, by F. H. Moffit and S. R. Capps. Bulletin 448, 1911, 111 pp.

Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts, by F. H. Moffit. Bulletin 498, 1912, 82 pp.

*The Chitina district, by F. H. Moffit. In Bulletin 520, 1912, pp. 105–107. 50 cents.

*Gold deposits near Valdez, by A. H. Brooks. In Bulletin 520, 1912, pp. 108–130. 50 cents.

Coastal glaciers of Prince William Sound and Kenai Peninsula, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 526, 1913, 75 pp.

The McKinley Lake district, by Theodore Chapin. In Bulletin 542, 1913, pp. 78–80.

Mining in Chitina Valley, by F. H. Moffit. In Bulletin 542, 1913, pp. 81–85.

Mineral deposits of the Ellamar district, by S. R. Capps and B. L. Johnson. In Bulletin 542, 1913, pp. 86–124.

The mineral deposits of the Yakataga region, by A. G. Maddren. In Bulletin 592, 1914, pp. 119–154.

*Preliminary report on water power of south-central Alaska, by C. E. Ellsworth and R. W. Davenport. In Bulletin 592, 1914, pp. 155–194.

The Port Wells gold lode district, by B. L. Johnson. In Bulletin 592, 1914, pp. 195–236.

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 592, 1914, pp. 237–244.

Geology of the Hanagita-Bremner region, by F. H. Moffit. Bulletin 576, 1915, 56 pp.

The geology and mineral resources of Kenai Peninsula, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587, 1915, 243 pp.

Mineral deposits of the Kotsina-Kuskulana district, with notes on mining in Chitina Valley, by F. H. Moffit. In Bulletin 622, 1915, pp. 103–117.

Auriferous gravels of the Nelchina-Susitna region, by Theodore Chapin. In Bulletin 622, 1915, pp. 118–130.

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 622, 1915, pp. 131–139.

The gold and copper deposits of the Port Valdez district, by B. L. Johnson. In Bulletin 622, 1915, pp. 140–188.

The Ellamar district, by S. R. Capps and B. L. Johnson. Bulletins 605, 125 pp.

A water-power reconnaissance in south-central Alaska, by C. E Ellsworth and R. W. Davenport. Water-Supply Paper 372, 173 pp.

Mineral resources of the upper Chitina Valley, by F. H. Moffit. In Bulletin 642, 1916, pp. 129–136.

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 642, 1916, pp. 137-145.

Mining in the lower Copper River basin, by F. H. Moffit. In Bulletin 662, 1917, pp. 155–182.

Retreat of Barry Glacier, Port Wells, Prince William Sound, Alaska, between 1910 and 1914, by B. L. Johnson. In Professional Paper 98, 1916, pp. 35–36.

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 662, 1917, pp. 183–192.

Copper deposits of the Latouche and Knight Island districts, Prince William Sound, by B. L. Johnson. In Bulletin 662, 1917, pp. 193–220.

The Nelchina-Susitna region, by Theodore Chapin. Bulletin 668, 1918, 67 pp.

The upper Chitina Valley, by F. H. Moffit, with a description of the igneous rocks, by R. M. Overbeck. Bulletin 675, 1918, 82 pp.

Platinum-bearing auriferous gravels of Chistochina River, by Theodore Chapin. In Bulletin 692, 1919, pp. 137–141.

Mining in Prince William Sound, by B. L. Johnson. In Bulletin 692, 1919, pp. 143–151.

The Jack Bay district and vicinity, by B. L. Johnson. In Bulletin 692, 1919, pp. 153–173.

Mining in central and northern Kenai Peninsula in 1917, by B. L. Johnson. In Bulletin 692, 1919, pp. 175–176.

Nickel deposits in the lower Copper River valley, by R. M. Overbeck. In Bulletin 712, 1920, pp. 91–98.

Preliminary report on chromite of Kenai Peninsula, by A. C. Gill. In Bulletin 712, 1920, pp. 99–129.

*In preparation.*

The Kotsina-Koskulana district, by F. H. Moffit.
The Latouche and Knight Island districts, Prince William Sound, Alaska, by B. L. Johnson.
The Valdez-Jack Bay district, Prince William Sound, Alaska, by B. L. Johnson.
The Yakataga region, by A. G. Maddren.
Chromite of Kenai Peninsula, Alaska, by A. C. Gill.

### TOPOGRAPHIC MAPS.

Central Copper River region, reconnaissance map; scale, 1:250,000; by T. G. Gerdine. In *Professional Paper 41. 50 cents. Not issued separately.
Headwater regions of Copper, Nabesna, and Chisana rivers, reconnaissance map; scale, 1:250,000; by D. C. Witherspoon, T. G. Gerdine, and W. J. Peters. In *Professional Paper 41. 50 cents. Not issued separately.
Controller Bay region (No. 601A); scale, 1:62,500; by E. G. Hamilton and W. R. Hill. 35 cents retail or 21 cents wholesale. Also published in *Bulletin 335. 70 cents.
Chitina quadrangle (No. 601), reconnaissance map; scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, and others. 50 cents retail or 30 cents wholesale. Also published in Bulletin 576.
Nizina district (No. 601B); scale, 1:62,500; by D. C. Witherspoon and R. M. La Follette. In Bulletin 448. Not issued separately.
Headwater regions of Gulkana and Susitna rivers; scale, 1:250,000; by D. C. Witherspoon, J. W. Bagley, and C. E. Giffin. In Bulletin 498. Not issued separately.
Prince William Sound; scale, 1:500,000; compiled. In Bulletin 526. Not issued separately.
Port Valdez district (No. 602B); scale, 1:62,500; by J. W. Bagley. 20 cents retail or 12 cents wholesale.
The Bering River coal fields; scale, 1:62,500; by G. C. Martin. 25 cents retail or 15 cents wholesale.
The Ellamar district (No. 602D); scale, 1:62,500; by R. H. Sargent and C. E. Giffin. Published in Bulletin 605. Not issued separately.
Nelchina-Susitna region; scale, 1:250,000; by J. W. Bagley, T. G. Gerdine, and others. In Bulletin 668. Not issued separately.
Upper Chitina Valley, reconnaissance map; scale, 1:250,000; contour interval, 200 feet; by International Boundary Commission, F. H. Moffit, D. C. Witherspoon, and T. G. Gerdine. In Bulletin 675. Not issued separately.

*In preparation.*

The Kotsina-Kuskulana district (No. 601C); scale, 1:62,500; by D. C. Witherspoon.
The Port Wells region; scale, 1:250,000; by J. W. Bagley.
Jack Bay district; scale, 1:62,500; by J. W. Bagley.

## COOK INLET AND SUSITNA REGION.

### REPORTS.

*The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, *4 pp. 15 cents.

*Gold placers of Turnagain Arm, Cook Inlet, by F. H. Moffit. In Bulletin 259, 1905, pp. 90–99. 15 cents.

*Mineral resources of the Kenai Peninsula, Alaska, by F. H. Moffit and R. W. Stone. Bulletin 277, 1906, 80 pp.

*Gold placers of the Mulchatna, by F. J. Katz. In Bulletin 442, 1910, pp. 201–202. 40 cents.

*Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska, by Sidney Paige and Adolph Knopf. Bulletin 327, 1907, 71 pp.

The Mount McKinley region, Alaska, by A. H. Brooks, with descriptions of the igneous rocks and of the Bonnifield and Kantishna districts, by L. M. Prindle. Professional Paper 70, 1911, 234 pp.

A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp.

Geology and coal fields of the lower Matanuska Valley, Alaska, by G. C. Martin and F. J. Katz. Bulletin 500, 1912, 98 pp.

The Yentna district, Alaska, by S. R. Capps. Bulletin 534, 1913, 75 pp.

Gold lodes and placers of the Willow Creek district, by S. R. Capps. In Bulletin 592, 1914, pp. 245–272.

Mineral resources of the upper Matanuska and Nelchina valleys, by G. C. Martin and J. B. Mertie, jr. In Bulletin 592, 1914, pp. 273–300.

Preliminary report on the Broad Pass region, by F. H. Moffit. In Bulletin 592, 1914, pp. 301–306.

Mining in the Valdez Creek placer district, by F. H. Moffit. In Bulletin 592, 1914, pp. 307–308.

The geology and mineral resources of Kenai Peninsula, Alaska, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587, 1915, 243 pp.

The Willow Creek district, by S. R. Capps. Bulletin 607, 1915, 86 pp.

The Broad Pass region, by F. H. Moffit and J. E. Pogue. Bulletin 608, 1915, 80 pp.

Auriferous gravels of the Nelchina-Susitna region, by Theodore Chapin. In Bulletin 622, 1915, pp. 118–130.

The Turnagain-Knik region, by S. R. Capps. In Bulletin 642, 1916, pp. 147–194,

Gold mining in the Willow Creek district, by S. R. Capps. In Bulletin 642, 1916, pp. 195–200.

The Nelchina-Susitna region, by Theodore Chapin. Bulletin 668, 1918, 67 pp.

Mineral resources of the upper Chulitna region, by S. R. Capps. In Bulletin 692, 1919, pp. 207–232.

Gold lode mining in the Willow Creek district, by S. R. Capps. In Bulletin 692, 1919, pp. 177–186.

Mineral resources of the western Talkeetna Mountains, by S. R. Capps. In Bulletin 692, 1919, pp. 187–205.

Platinum-bearing gold placers of Kahiltna Valley, by J. B. Mertie, jr. In Bulletin 692, 1919, pp. 233–264.

Chromite deposits of Alaska, by J. B. Mertie, jr. In Bulletin 692, 1919, pp. 265–267.

Geologic problems at the Matanuska coal mines, by G. C. Martin. In Bulletin 692, 1919, pp. 269–282.

Preliminary report on chromite of Kenai Peninsula, by A. C. Gill. In Bulletin 712, 1920, pp. 99–129.

Mining developments in the Matanuska coal field, by Theodore Chapin. In Bulletin 712, 1920, pp. 131–167.

Lode developments in the Willow Creek district, by Theodore Chapin. In Bulletin 712, 1920, pp. 169–176.

*In preparation.*

The geology of upper Matanuska basin, by G. C. Martin.
The western Talkeetna Mountains, Alaska, by S. R. Capps.
Chromite of Kenai Peninsula, Alaska, by A. C. Gill.
The Seward-Fairbanks route, by S. R. Capps.

### TOPOGRAPHIC MAPS.

Kenai Peninsula, southern portion; scale, 1:500,000; compiled. In Bulletin 526. Not issued separately.

Matanuska and Talkeetna region, reconnaissance map; scale, 1:250,000; by T. G. Gerdine and R. H. Sargent. In * Bulletin 327. 25 cents. Not issued separately.

Lower Matanuska Valley; scale, 1:62,500; by R. H. Sargent. In Bulletin 500. Not issued separately.

Yentna district, reconnaissance map; scale, 1:250,000; by R. W. Porter. Revised edition. In Bulletin 534. Not issued separately.

Mount McKinley region, reconnaissance map; scale, 1:625,000; by D. L. Reaburn. In Professional Paper 70. Not issued separately.

Kenai Peninsula, reconnaissance map; scale, 1:250,000; by R. H. Sargent, J. W. Bagley, and others. In Bulletin 587. Not issued separately.

Mosse Pass and vicinity (602C); scale, 1:62,500; by J. W. Bagley. In Bulletin 587. Not issued separately.

The Willow Creek district; scale, 1:62,500; by C. E. Giffin. In Bulletin 607. Not issued separately.

The Broad Pass region; scale, 1:250,000; by J. W. Bagley. In Bulletin 608. Not issued separately.

Lower Matanuska Valley (602A); scale, 1:62,500; contour interval, 50 feet; by R. H. Sargent. 10 cents.

Nelchina-Susitna region; scale, 1:250,000; by J. W. Bagley. In Bulletin 668. Not issued separately.

*In preparation.*

The Seward-Fairbanks route; compiled; scale, 1:250,000.

## SOUTHWESTERN ALASKA.

### REPORTS.

*Areconnaissance in southwestern Alaska, by J. E. Spurr. In Twentieth Annual Report, pt. 7, 1900, pp. 31–264. $1.80.

*Gold mine on Unalaska Island, by A. J. Collier. In Bulletin 259, 1905, pp. 102–103. 15 cents.

*The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp. 15 cents.

Geology and mineral resources of parts of Alaska Peninsula, by W. W. Atwood. Bulletin 467, 1911, 137 pp.

A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp.

Mineral deposits of Kodiak and the neighboring islands, by G. C. Martin. In Bulletin 542, 1913, pp. 125–136.

The Lake Clark-Central Kuskokwim region, by P. S. Smith. Bulletin 655, 1918, 162 pp.

Beach placers of Kodiak Island, Alaska, by A. G. Maddren. In Bulletin 692, 1919, pp. 299–319.

Sulphur on Unalaska and Akun islands and near Stepovak Bay, Alaska, by A. G. Maddren. In Bulletin 692, 1919, pp. 283–298.

### TOPOGRAPHIC MAPS.

Herendeen Bay and Unga Island region, reconnaissance map; scale, 1:250,000; by H. M. Eakin. In Bulletin 467. Not issued separately.

Chignik Bay region, reconnaissance map; scale, 1:250,000; by H. M. Eakin. In Bulletin 467. Not issued separately.

Iliamna region, reconnaissance map; scale, 1:250,000; by D. C. Witherspoon and C. E. Giffin. In Bulletin 485. Not issued separately.

*Kuskokwim River and Bristol Bay region; scale, 1:625,000; by W. S. Post. In Twentieth Annual Report, pt. 7. $1.80. Not issued separately.

Lake Clark-Central Kuskokwim region, reconnaissance map; scale, 1:250,000; by R. H. Sargent, D. C. Witherspoon, and C. E. Giffin. In Bulletin 655. Not issued separately.

## YUKON AND KUSKOKWIM BASINS.

### REPORTS.

*The coal resources of the Yukon, Alaska, by A. J. Collier. Bulletin 218, 1903, 71 pp. 15 cents.

*Occurrence of gold in the Yukon-Tanana region, by L. M. Prindle. In Bulletin 345, 1908, pp. 179–186. 45 cents.

The Fortymile quadrangle, Yukon-Tanana region, Alaska, by L. M. Prindle. Bulletin 375, 1909, 52 pp.

Water-supply investigations in Yukon-Tana region, Alaska, 1907–8 (Fairbanks, Circle, and Rampart districts), by C. C. Covert and C. E. Ellsworth. Water-Supply Paper 228, 1909, 108 pp.

The Innoko gold placer district, Alaska, with accounts of the Central Kuskokwim Valley and the Ruby Creek and Gold Hill placers, by A. G. Maddren. Bulletin 410, 1910, 87 pp.

Mineral resources of Nabesna-White River district, by F. H. Moffit and Adolph Knopf, with a section on the Quarternary by S. R. Capps. Bulletin 417, 1910, 64 pp.

*Placer mining in the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 230–245. 40 cents.

*Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district, by B. L. Johnson. In Bulletin 442, 1910, pp. 246–250. 40 cents.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, pp. 153–172.

Gold placer-mining developments in the Innoko-Iditarod region, by A. G. Maddren. In Bulletin 480, 1911, pp. 236–270.

Placer mining in the Fortymile and Seventymile river districts, by E. A. Porter. In *Bulletin 520, 1912, pp. 211–218. 50 cents.

Placer mining in the Fairbanks and Circle districts, by C. E. Ellsworth. In *Bulletin 520, 1912, pp. 240–245. 50 cents.

Gold placers between Woodchopper and Fourth of July creeks, upper Yukon River, by L. M. Prindle and J. B. Mertie, jr. In *Bulletin 520, 1912, pp. 201–210. 50 cents.

The Bonnifield region, Alaska, by S. R. Capps. Bulletin 501, 1912, 162 pp.

A geologic reconnaissance of a part of the Rampart quadrangle, Alaska, by H. M. Eakin. Bulletin 535, 1913, 38 pp.

A geologic reconnaissance of the Fairbanks quadrangle, Alaska, by L. M. Prindle, with a detailed description of the Fairbanks district, by L. M. Prindle and F. J. Katz, and an account of lode mining near Fairbanks, by P. S. Smith. Bulletin 525, 1913, 220 pp.

The Koyukuk-Chandalar region, Alaska, by A. G. Maddren. Bulletin 532, 1913, 119 pp. Price 25 cents.

A geologic reconnaissance of the Circle quadrangle, Alaska, by L. M. Prindle. Bulletin 538, 1913, 82 pp.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and R. W. Davenport. In Bulletin 542, 1913, pp. 203–222.

The Chisana placer district, by A. H. Brooks. In *Bulletin 592, 1914, pp. 309–320.

*Placer mining in the Yukon-Tanana region, by Theodore Chapin. In Bulletin 592, 1914, pp. 357–362. 60 cents.

*Lode developments near Fairbanks, by Theodore Chapin. In Bulletin 592, 1914, pp. 321–355. 60 cents.

Mineral resources of the Yukon-Koyukuk region, by H. M. Eakin. In *Bulletin 592, 1914, pp. 371–384.

The Iditarod-Ruby region, Alaska, by H. M. Eakin. Bulletin 578, 1914, 45 pp.

Surface water supply of the Yukon-Tanana region, 1907 to 1912, by C. E. Ellsworth and R. W. Davenport. Water-Supply Paper 342, 1915, 343 pp.

Mineral resources of the Chisana-White River district, by S. R. Capps. In Bulletin 622, 1915, pp. 189–228.

Mining in the Fairbanks district, by H. M. Eakin. In Bulletin 622, 1915, pp. 229–238.

Mining in the Hot Springs district, by H. M. Eakin. In Bulletin 622, 1915, pp. 239–245.

Mineral resources of the Lake Clark-Iditarod region, by P. S. Smith. In Bulletin 622, 1915, pp. 247–271.

Quicksilver deposits of the Kuskokwim region, by P. S. Smith and A. G. Maddren. In Bulletin 622, 1915, pp. 272–291.

Gold placers of the lower Kuskokwim, by A. G. Maddren. In Bulletin 622, 1915, pp. 292–360.

An ancient volcanic eruption in the upper Yukon Basin, by S. R. Capps. Professional Paper 95–D, 1915, pp. 59–64.

Preliminary report on Tolovana district, by A. H. Brooks. In Bulletin 642, 1916, pp. 201–209.

Exploration in the Cosna-Nowitna region, by H. M. Eakin. In Bulletin 642, 1916, pp. 211–222.

Mineral resources of the Ruby-Kuskokwim region, by J. B. Mertie, jr., and G. L. Harrington. In Bulletin 642, 1916, pp. 228–266.

The Chisana-White River district, by S. R. Capps. Bulletin 630, 1916, 130 pp.

The Yukon-Koyukuk region, by H. M. Eakin. Bulletin 631, 1916, 88 pp.

Mineral resources of the Kantishna region, by S. R. Capps. In Bulletin 662, 1917, pp. 279–331.

The gold placers of the Tolovana district, by J. B. Mertie, jr. In Bulletin 662, 1917, pp. 221–277.

Gold placers near the Nenana coal field, by A. G. Maddren. In Bulletin 662, 1917, pp. 363–402.

Lode mining in the Fairbanks district, by J. B. Mertie, jr. In Bulletin 662, 1917, pp. 403–424.

Lode deposits near the Nenana coal field, by R. M. Overbeck. In Bulletin 662, 1917, pp. 351–362.

Gold placers of the Anvik-Andreafski region, by G. L. Harrington. In Bulletin 662, 1917, pp. 333–349.

The Lake Clarke-Central Kuskokwim region, by P. S. Smith. Bulletin 655, 1918, 162 pp.

The Cosna-Nowitna region, by H. M. Eakin. Bulletin 667, 1918, 54 pp.

The Anvik-Andreafski region, by G. L. Harrington. Bulletin 683, 1918, 70 pp.

The Kantishna district, by S. R. Capps. Bulletin 687, 1919, 116 pp.

The Nenana coal fields, by G. C. Martin. Bulletin 664, 1919, 54 pp.

Mining in the Fairbanks district, by Theodore Chapin. In Bulletin 692, 1919, pp. 321–327.

A molybdenite lode on Healy River, by Theodore Chapin. In Bulletin 692, 1919, p. 329.

Mining in the Hot Springs district, by Theodore Chapin. In Bulletin 692, 1919, pp. 331–335.

Tin deposits of the Ruby district, by Theodore Chapin. In Bulletin 692, 1919, p. 337.

The gold and platinum placers of the Tolstoi district, by G. L. Harrington. In Bulletin 692, 1919, pp. 338–351.

Placer mining in the Tolovana district, by R. M. Overbeck. In Bulletin 712, 1920, pp. 177–184.

*In preparation.*

The Ruby-Kuskokwim region, by J. B. Mertie, jr., and G. L. Harrington.

The lower Kuskokwim region, by A. G. Maddren.

A geologic reconnaissance in the northern part of the Yukon-Tanana region, Alaska, by Eliot Blackwelder.

**TOPOGRAPHIC MAPS.**

Circle quadrangle (No. 641); scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, and others. 50 cents retail or 30 cents wholesale. Also in *Bulletin 295. 35 cents.

Fairbanks quadrangle (No. 642); scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, R. B. Oliver, and J. W. Bagley. 50 cents retail or 30 cents wholesale. Also in *Bulletins 337 (25 cents) and 525.

Fortymile quadrangle (No. 640); scale, 1:250,000; by E. C. Barnard. 10 cents retail or 6 cents wholesale. Also in Bulletin 375.

Rampart quadrangle (No. 643); scale, 1:250,000; by D. C. Witherspoon and R. B. Oliver. 20 cents retail or 12 cents wholesale. Also in *Bulletin 337 (25 cents) and part in Bulletin 535.

Fairbanks special (No. 642A); scale, 1:62,500; by T. G. Gerdine and R. H. Sargent. 20 cents retail or 12 cents wholesale. Also in Bulletin 525.

Bonnifield region; scale, 1:250,000; by J. W. Bagley, D. C. Witherspoon, and C. E. Giffin. In Bulletin 501. Not issued separately.

Iditarod-Ruby region, reconnaissance map; scale, 1:250,000; by C. G. Anderson, W. S. Post, and others. In Bulletin 578. Not issued separately.

Middle Kuskokwim and lower Yukon region; scale, 1:500,000; by C. G. Anderson, W. S. Post, and others. In Bulletin 578. Not issued separately.

Chisana-White River region; scale, 1:250,000; by C. E. Giffin and D. C. Witherspoon. In Bulletin 630. Not issued separately.

Yukon-Koyukuk region; scale, 1:500,000; by H. M. Eakin. In Bulletin 631. Not issued separately.

Cosna-Nowitna region, reconnaissance map; scale, 1:250,000; by H. M. Eakin, C. E. Giffin, and R. B. Oliver. In Bulletin 667. Not issued separately.

Lake Clark-Central Kuskokwim region, reconnaissance map; scale, 1:250,000; by R. H. Sargent, D. C. Witherspoon, and C. E. Giffin. In Bulletin 655. Not issued separately.

Anvik-Andreafski region; scale, 1:250,000; by R. H. Sargent. In Bulletin 683. Not issued separately.

Marshall district; scale, 1:125,000; by R. H. Sargent. In Bulletin 683. Not issued separately.

*In preparation.*

Lower Kuskokwim region; scale, 1:500,000; by A. G. Maddren.

Ruby district; scale, 1:250,000; by C. E. Giffin and R. H. Sargent.

Innoko-Iditarod district; scale, 1:250,000; by R. H. Sargent and C. E. Giffin.

## SEWARD PENINSULA.

### REPORTS.

The Fairhaven gold placers of Seward Peninsula, Alaska, by F. H. Moffit. Bulletin 247, 1905, 85 pp.

Gold mining on Seward Peninsula, by F. H. Moffit. In Bulletin 284, 1906, pp. 132–141.

The Kougarok region, by A. H. Brooks. In Bulletin 314, 1907, pp. 164–181.

Geology and mineral resources of Iron Creek, by P. S. Smith. In Bulletin 314, 1907, pp. 157–163.

The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks. Bulletin 328, 1908, 343 pp.

*Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin 345, 1908, pp. 206–250. 45 cents.

Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358, 1908, 72 pp.

Recent developments in southern Seward Peninsula, by P. S. Smith. In *Bulletin 379, 1909, pp. 267–301.

*The Iron Creek region, by P. S. Smith. In Bulletin 379, 1909, pp. 302–354. 50 cents.

*Mining in the Fairhaven district, by F. F. Henshaw. In Bulletin 379, 1909, pp. 355–369. 50 cents.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, Alaska, by P. S. Smith. Bulletin 433, 1910, 227 pp.

Mining in Seward Peninsula, by F. F. Henshaw. In *Bulletin 442, 1910, pp. 353–371.

A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, by P. S. Smith and H. M. Eakin. Bulletin 449, 1911, 146 pp.

*Notes on mining in Seward Peninsula, by P. S. Smith. In Bulletin 520, 1912, pp. 339–344. 50 cents.

Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Moffit. Bulletin 533, 1913, 140 pp.

*Surface water supply of Seward Peninsula, Alaska, by F. F. Henshaw and G. L. Parker, with a sketch of the geography and geology by P. S. Smith and a description of methods of placer mining by A. H. Brooks; including topographic reconnaissance map. Water-Supply Paper 314, 1913, 317 pp. 45 cents.

*Placer mining on Seward Peninsula, by Theodore Chapin. In Bulletin 592, 1914, pp. 385–396. 60 cents.

*Lode developments on Seward Peninsula, by Theodore Chapin. In Bulletin 592, 1914, pp. 397–407. 60 cents.

Iron-ore deposits near Nome, by H. M. Eakin. In Bulletin 622, 1915, pp. 361–365.

Placer mining in Seward Peninsula, by H. M. Eakin. In Bulletin 622, 1915, pp. 366–373.

Lode mining and prospecting on Seward Peninsula, by J. B. Mertie, jr. In Bulletin 662, 1917, pp. 425–449.

Placer mining on Seward Peninsula, by J. B. Mertie, jr. In Bulletin 662, 1917, pp. 451–458.

Tin mining in Seward Peninsula, by G. L. Harrington. In Bulletin 692, 1919, pp. 353–361.

Graphite mining in Seward Peninsula, by G. L. Harrington. In Bulletin 692, 1919, pp. 363–367.

The gold and platinum placers of the Kiwalik-Koyuk region, by G. L. Harrington. In Bulletin 692, 1919, pp. 368–400.

Mining in northwestern Alaska, by S. H. Cathcart. In Bulletin 712, 1920, pp. 185–198.

### TOPOGRAPHIC MAPS.

Seward Peninsula; scale, 1:500,000; compiled from work of D. C. Witherspoon, T. G. Gerdine, and others, of the Geological Survey, and all available sources. In Water-Supply Paper 314. Not issued separately.

Seward Peninsula, northeastern portion, reconnaissance map (No. 655); scale, 1:250,000; by D. C. Witherspoon and C. E. Hill. 50 cents retail or 30 cents wholesale. Also in Bulletin 247.

Seward Peninsula, northwestern portion, reconnaissance map (No. 657); scale, 1:250,000; by T. G. Gerdine and D. C. Witherspoon. 50 cents retail or 30 cents wholesale. Also in Bulletin 328.

Seward Peninsula, southern portion, reconnaissance map (No. 656); scale, 1:250,000; by E. C. Barnard, T. G. Gerdine, and others. 50 cents retail or 30 cents wholesale. Also in Bulletin 328.

Seward Peninsula, southeastern portion, reconnaissance map (Nos. 655–656); scale, 1:250,000; by E. C. Barnard, D. L. Reaburn, H. M. Eakin, and others. In Bulletin 449. Not issued separately.

Nulato-Norton Bay region; scale, 1:500,000; by P. S. Smith, H. M. Eakin, and others. In Bulletin 449. Not issued separately.

Grand Central quadrangle (No. 646A); scale, 1:62,500; by T. G. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents retail or 6 cents wholesale. Also in Bulletin 533.

Nome quadrangle (No. 646B); scale, 1:62,500; by T. G. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents retail or 6 cents wholesale. Also in Bulletin 533.

Casadepaga quadrangle (No. 646C); scale, 1:62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder. 10 cents retail or 6 cents wholesale. Also in Bulletin 433.

Solomon quadrangle (No. 646D); scale, 1:62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder. 10 cents retail or 6 cents wholesale. Also in Bulletin 433.

## NORTHERN ALASKA.

### REPORTS.

*A reconnaissance in northern Alaska across the Rocky Mountains, along Koyukuk, John, Anaktuvuk, and Colville Rivers and the Arctic coast to Cape Lisburne in 1901, by F. C. Schrader, with notes by W. J. Peters. Professional Paper 20, 1904, 139 pp. 40 cents.

*Geology and coal resources of the Cape Lisburne region, Alaska, by A. J. Collier. Bulletin 278, 1906, 54 pp. 15 cents.

Geologic investigations along the Canada-Alaska boundary, by A. G. Maddren. In *Bulletin 520, 1912 ,pp. 297–314.

The Noatak-Kobuk region, by P. S. Smith. Bulletin 536, 1913, 160 p.

The Koyukuk-Chandalar region, Alaska, by A. G. Maddren. Bulletin 532, 1913, 119 pp.

The Canning River region of northern Alaska, by E. de K. Leffingwell. Professional Paper 109, 1919, 251 pp.

### TOPOGRAPHIC MAPS.

*Koyukuk River to mouth of Colville River, including John River; scale, 1:1,250,000; by W. J. Peters. In *Professional Paper 20. 40 cents. Not issued separately.

Koyukuk and Chandalar region, reconnaissance map; scale, 1:500,000; by T. G. Gerdine, D. L. Reaburn, D. C. Witherspoon, and A. G. Maddren. In Bulletin 532. Not issued separately.

Noatak-Kobuk region; scale, 1:500,000; by C. E. Giffin, D. L. Reaburn, H. M. Eakin, and others. In Bulletin 536. Not issued separately.

Canning River Region; scale, 1:250,000; by E. de K. Leffingwell. In Professional Paper 109. Not issued separately.

North Arctic coast; scale, 1:1,000,000; by E. de K. Leffingwell. In Professional Paper 109. Not issued separately.

Martin Point to Thetis Island; scale, 1:125,000; by E. de K. Leffingwell. In Professional Paper 109. Not issued separately.

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